

# SCIENCE

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## THE HUMAN SIGNIFICANCE OF MATHEMATICS<sup>1</sup>

Homo sum; humani nil a me alienum puto.—Terence.

THE subject of this address is not of my choosing. It came to me by assignment. I may, therefore, be allowed to say that it is in my judgment ideally suited to the occasion. This meeting is held here upon this beautiful coast because of the presence of an international exposition, and we are thus invited to a befitting largeness and liberality of spirit. An international exposition properly may and necessarily will admit many things of a character too technical to be intelligible to any one but the expert and the specialist. Such things, however, are only incidental—contributory, indeed, yet incidental—to pursuit of the principal aim, which is, I believe, or ought to be, the representation of human things as human—an exhibition and interpretation of industries, institutions, sciences and arts, not primarily in their accidental or particular character as illustrating individuals or classes or specific localities or times, but primarily in their essential and universal character as representative of man. A world-exposition will, therefore, as far as practicable, avoid placing in the forefront matters so abstruse as to be fit for the contemplation and understanding of none but specialists; it will, as a whole, and in all its principal parts, address itself to the general intelligence; for it aims at being, for the multitudes of men and

<sup>1</sup> An address delivered August 3, 1915, Berkeley, Calif., at a joint meeting of the American Mathematical Society, the American Astronomical Society, and Section A of the American Association for the Advancement of Science.

women who avail themselves of its exhibitions and lessons, an exposition of humanity: an exposition, no doubt, of the activities and aspirations and prowess of individual men and women, but of men and women, not in their capacity as individuals, but as representatives of humankind. Individual achievements are not the object, they are the means, of the exposition. The object is humanity.

What is the human significance—what is the significance for humanity—of “the mother of the sciences”? And how may the matter be best set forth, not for the special advantage of professional mathematicians, for I shall take the liberty of having these but little in mind, but for the advantage and understanding of educated men and women in general? I am unable to imagine a more difficult undertaking, so technical, especially in its language, and so immense is the subject. It is clear that the task is far beyond the resources of an hour’s discourse, and so it is necessary to restrict and select. This being the case, what is it best to choose? The material is superabundant. What part of it or aspect of it is most available for the end in view? “In abundant matter to speak a little with elegance,” says Pindar, “is a thing for the wise to listen to.” It is not, however, a question of elegance. It is a question of emphasis, of clarity, of effectiveness. What shall be our major theme?

Shall it be the history of the subject? Shall it be the modern developments of mathematics, its present status and its future outlook? Shall it be the utilities of the science, its so-called applications, its service in practical affairs, in engineering and in what it is customary to call the sciences of nature? Shall it be the logical foundations of mathematics, its basic principles, its inner nature, its characteristic processes and structure, the differences and

similitudes that come to light in comparing it with other forms of scientific and philosophic activity? Shall it be the bearings of the science as distinguished from its applications—the bearings of it as a spiritual enterprise upon the higher concerns of man as man? It might be any one of these things. They are all of them great and inspiring themes.

It is easy to understand that a historian would choose the first. The history of mathematics is indeed impressive, but is it not too long and too technical? And is it not already accessible in a large published literature of its own? I grant, the historian would say, that its history is long, for in respect of antiquity mathematics is a rival of art, surpassing nearly all branches of science and by none of them surpassed. I grant that, for laymen, the history is technical, frightfully technical, requiring interpretation in the interest of general intelligence. I grant, too, that the history owns a large literature, but this, the historian would say, is not designed for the general reader, however intelligent, the numerous minor works, no less than the major ones, including that culminating monumental work of Moritz Cantor, being, all of them, addressed to specialists and intelligible to them alone. And yet it would be possible to tell in one hour, not indeed the history of mathematics, but a true story of it that would be intelligible to all and would show its human significance to be profound, manifold and even romantic. It would be possible to show historically that this science, which now carries its head so high in the tenuous atmosphere of pure abstractions, has always kept its feet upon the solid earth; it would be possible to show that it owns indeed a lowly origin, in the familiar needs of common life, in the homely necessities of counting herds and measuring lands; it would be possible to



show that, notwithstanding its birth in the concrete things of sense and raw reality, it yet so appealed to sheer intellect—and we must not forget that creative intellect is the human faculty par excellence—it so appealed to this distinctive and disinterested faculty of man that, long before the science rose to the level of a fine art in the great days of Euclid and Archimedes, Plato in the wisdom of his maturer years judged it essential to the education of freemen because, said he, there is in it a necessary something against which even God can not contend and without which neither gods nor demi-gods can wisely govern mankind; it would be possible, our historian could say, to show historically to educated laymen that, even prior to the inventions of analytical geometry and the infinitesimal calculus, mathematics had played an indispensable rôle in the “Two New Sciences” of physics and mechanics in which Galileo laid the foundations of our modern knowledge of nature; it would be possible to show not only that the analytical geometry of Descartes and Fermat and the calculus of Leibnitz and Newton have been and are essential to our still advancing conquest of the sea, but that it is owing to the power of these instruments that the genius of such as Newton, Laplace and Lagrange has been enabled to create for us a new earth and a new heavens compared with which the Mosaic cosmogony or the sublimest creation of the Greek imagination is but “as a cabinet of brilliants, or rather a little jewelled cup found in the ocean or the wilderness”; it would be possible to show historically that, just because the pursuit of mathematical truth has been for the most part disinterested—led, that is, by wonder, as Aristotle says, and sustained by the love of beauty with the joy of discovery—it would be possible to show that, just because of the disinterestedness of mathe-

matical research, this science has been so well prepared to meet everywhere and always, as they have arisen, the mathematical exigencies of natural science and engineering; above all, it would be feasible to show historically that to the same disinterestedness of motive operating through the centuries we owe the upbuilding of a body of pure doctrine so towering to-day and vast that no man, even though he have the “Andean intellect” of a Poincaré, can embrace it all. This much, I believe, and perhaps more, touching the human significance of mathematics, a historian of the science might reasonably hope to demonstrate in one hour.

More difficult, far more difficult, I think, would be the task of a pure mathematician who aimed at an equivalent result by expounding, or rather by delineating, for he could not in one hour so much as begin to expound, the modern developments of the subject. Could he contrive even to delineate them in a way to reveal their relation to what is essentially humane? Do but consider for a moment the nature of such an enterprise. Mathematics may be legitimately pursued for its own sake or for the sake of its applications or with a view to understanding its logical foundations and internal structure or in the interest of magnanimity or for the sake of its bearings upon the supreme concerns of man as man or from two or more of these motives combined. Our supposed delineator is actuated by the first of them: his interest in mathematics is an interest in mathematics for the sake of mathematics; for him the science is simply a large and growing body of logical consistencies or compatibilities; he derives his inspiration from the muse of intellectual harmony; he is a pure mathematician. He knows that pure mathematics is a house of many chambers; he knows that its foundations lie far beneath

the level of common thought; and that the superstructure, quickly transcending the power of imagination to follow it, ascends higher and higher, ever keeping open to the sky; he knows that the manifold chambers—each of them a mansion in itself—are all of them connected in wondrous ways, together constituting a fit laboratory and dwelling for the spirit of men of genius. He has assumed the task of presenting a vision of it that shall be worthy of a world-exposition. Can he keep the obligation? He wishes to show that the life and work of pure mathematicians are human life and work: he desires to show that these toilers and dwellers in the chambers of pure thought are representative men. He would exhibit the many-chambered house to the thronging multitudes of his fellow men and women; he would lead them into it; he would conduct them from chamber to chamber by the curiously winding corridors, passing now downward, now upward, by delicate passage-ways and subtle stairs; he would show them that the wondrous castle is not a dead or static affair like a structure of marble or steel, but a living architecture, a living mansion of life, human as their own; he would show them the mathetic spirit at work, how it is ever weaving, tirelessly weaving, fabrics of beauty, finer than gossamer yet stronger than cables of steel; he would show them how it is ever enlarging its habitation, deepening its foundations, expanding more and more and elevating the superstructure; and, what is even more amazing, how it perpetually performs the curious miracle of permanence combined with change, transforming, that is, the older portions of the edifice without destroying it, for the structure is eternal: in a word, he would show them a vision of the whole, and he would do it in a way to make them perceive and feel that, in thus

beholding there a partial and progressive attainment of the higher ideals of man, they were but gazing upon a partial and progressive realization of their own appetitions and dreams.

That is what he *would* do. But how? *Mengenlehre*, *Zahlenlehre*, algebras of many kinds, countless geometries of countless infinite spaces, function theories, transformations, invariants, groups and the rest—how can these with all their structural finesse, with their heights and depths and limitless ramifications, with their labyrinthine and interlocking modern developments—I will not say how can they be presented in the measure and scale of a great exposition—but how is it possible in one hour to give laymen even a glimpse of the endless array? Nothing could be more extravagant or more absurd than such an undertaking. Compared with it, the American traveler's hope of being able to see Rome in a single forenoon was a most reasonable expectation. But it is worth while trying to realize how stupendous the absurdity is.

It is evident that our would-be delineator must compromise. He can not expound, he can not exhibit, he can not even delineate the doctrines whose human worth he would thus disclose to his fellow men and women. The fault is neither his nor theirs. It must be imputed to the nature of things. But he need not, therefore, despair and he need not surrender. The method he has proposed—the method of exposition—that indeed he must abandon as hopeless, but not his aim. He is addressing men and women who are no doubt without his special knowledge and his special discipline, as he in his turn is without theirs, but who are yet essentially like himself. He would have them as fellows and comrades persuaded of the dignity of his *Fach*: he would have them feel that it is also theirs; he would



have them convinced that mathematics stands for an immense body of human achievements, for a diversified continent of pure doctrine, for a discovered world of intellectual harmonies. He can not *show* it to them as a painter displays a canvas or as an architect presents a cathedral. He can not give them an immediate vision of it, but he can give them intimations; by appealing to their *fantasie* and, through analogy with what they know, to their understanding, not only can he convince them that his world exists, but he can give them an intuitive apprehension of its living presence and its meaning for humankind. This is possible because, like him, they, too, are idealists, dreamers and poets—such essentially are all men and women. His auditors or his readers have all had *some* experience of ideas and of truth, they have all had inklings of more beyond, they have all been visited and quickened by a sense of the limitless possibilities of further knowledge in every direction, they have all dreamed of the perfect and have felt its lure. They are thus aware that the small implies the large; having seen hills, they can believe in mountains; they know that Euripides, Shakespeare, Dante, Goethe, are but fulfillments of prophecies heard in peasant tales and songs; they know that the symphonies of Beethoven or the dramas of Wagner are harbingered in the melodies and the sighs of those who garner grain and in their hearts respond to the music of the winds or the “solemn anthems of the sea”; they sense the secret by which the astronomy of Newton and Laplace is foretold in the shepherd’s watching of the stars; and knowing thus this plain spiritual law of progressiveness and implication, they are prepared to grasp the truth that modern mathematics, though they do not understand it, is, like the other great things, but a sublime fulfillment, the realization of

prophecies involved in what they themselves, in common with other educated folk, know of the rudiments of the science. Indeed, they would marvel if upon reflection it did not seem to be so. Our pure mathematician in speaking to his fellow men and women of his science will have no difficulty in persuading them that he is speaking of a subject immense and eternal. As born idealists they have intimations of their own—the evidence of intuition, if you please—or a kind of insight resembling that of the mystic—that in the world of mind there must be something deeper and higher, stabler and more significant, than the pitiful ideas in life’s routine and the familiar vocations of men. They are thus prepared to believe, before they are told, that behind the veil there exists a universe of exact thought, an everlasting cosmos of ordered ideas, a stable world of concatenated truth. In their study of the elements, in school or college, they may have caught a shimmer of it or, in rare moments of illumination, even a gleam. Of the existence, the reality, the actuality, of our pure mathematician’s world they will have no doubt, and they will have no doubt of its grandeur. They may even, in a vague way, magnify it overmuch, feeling that it is, in some wise, *more* than human, significant only for the rarely gifted spirit that dwells, like a star, apart. The pure mathematician’s difficulty lies in showing, in *his* way, that such is not the case. For he does not wish to adduce utilities and applications. He is well aware of these. He knows that if he “would tell them they are more in number than the sands.” Neither does he despise them as of little moment. On the contrary, he values them as precious. But he wishes to do his subject and his auditors the honor of speaking from a higher level: he desires to vindicate the worth of mathematics on the ground of its

sheer ideality, on the ground of its intellectual harmony, on the ground of its beauty, "free from the gorgeous trappings" of sense, pure, austere, supreme. To do this, which ought, it seems, to be easy, experience has shown to be exceedingly difficult. For the multitude of men and women, even the educated multitude, are wont to cry,

Such knowledge is too wonderful for me,  
It is too high, I can not attain unto it,

thus meaning to imply, What, then, or where is its human significance? Their voice is heard in the challenge once put to me by the brilliant author of "East London Visions." What, said he, can be the human significance of "this majestic intellectual cosmos of yours, towering up like a million-lusted iceberg into the arctic night," seeing that, among mankind, none is permitted to behold its more resplendent wonders save the mathematician alone? What response will our pure mathematician make to this challenge? Make, I mean, if he be not a wholly naïve devotee of his science and so have failed to reflect upon the deeper grounds of its justification. He may say, for one thing, what Professor Klein said on a similar occasion:

Apart from the fact that pure mathematics can not be supplanted by anything else as a means for developing the purely logical faculties of the mind, there must be considered here, as elsewhere, the necessity of the presence of a few individuals in each country developed in far higher degree than the rest, for the purpose of keeping up and gradually raising the *general* standard. Even a slight raising of the general level can be accomplished only when some few minds have progressed far ahead of the average.

That is doubtless a weighty consideration. But is it all or the best that may be said? It is just and important but it does not go far enough; it is not, I fear, very convincing; it is wanting in pungence and edge; it does not touch the central nerve of

the challenge. Our pure mathematician must rally his sceptics with sharper considerations. He may say to them: You challenge the human significance of the higher developments of pure mathematics because they are inaccessible to all but a few, because their charm is esoteric, because their deeper beauty is hid from nearly all mankind. Does that consideration justify your challenge? You are individuals, but you are also members of a race. Have you as individuals no human interest nor human pride in the highest achievements of your race? Is nothing human, is nothing humane, except mediocrity and the commonplace? Was Phidias or Michel Angelo less human than the carver and painter of a totem-pole? Was Euclid or Gauss or Poincaré less representative of man than the countless millions for whom mathematics has meant only the arithmetic of the market place or the rude geometry of the carpenter? Does the quality of humanity in human thoughts and deeds decrease as they ascend towards the peaks of achievement, and increase in proportion as they become vulgar, attaining an upper limit in the beasts? Do you not know that precisely the reverse is true? Do you not count aspiration humane? Do you not see that it is not the common things that every one may reach, but excellences high-dwelling among the rocks—do you not know that, in respect of human worth, these things, which but few can attain, are second only to the supreme ideals attainable by none?

How very different and how very much easier the task of one who sought to vindicate the human significance of mathematics on the ground of its applications! In respect of temperamental interest, of attitude and outlook, the difference between the pure and the applied mathematician is profound. It is—if we may liken spiritual



things to things of sense—much like the difference between one who greets a new-born day because of its glory and one who regards it as a time for doing chores and values its light only as showing the way. For the former, mathematics is justified by its supreme beauty; for the latter, by its manifold use. But are the two kinds of value essentially incompatible? They are certainly not. The difference is essentially a difference of authority—a difference, that is, of worth, of elevation, of excellence. The pure mathematician and the applied mathematician sometimes may, indeed they not infrequently do, dwell together harmoniously in a single personality. If our spokesman be such a one—and I will not suppose the shame of having the utilities of the science represented on such an occasion by one incapable of regarding it as anything but a tool, for that would be disgraceful—if, then, our spokesman be such a one as I have supposed, he might properly begin as follows: In speaking to you of the applications of mathematics I would not have you suppose, ladies and gentlemen, that I am thus presenting the *highest* claims of the science to your regard; for its highest justification is the charm of its immanent beauty; I do not mean, he will say, the beauty of appearances—the fleeting beauties of sense, though these, too, are precious—even the outer garment, the changeful robe, of reality is a lovely thing; I mean the eternal beauty of the world of pure thought; I mean intellectual beauty; in mathematics this nearly attains perfection; and “intellectual beauty is self-sufficing”; uses, on the other hand, are not; they wear an aspect of apology; uses resemble excuses, they savor a little of a plea in mitigation. Do you ask: Why, then, plead them? Because, he will say, many good people have a natural incapacity to ap-

preciate anything else; because, also, many of the applications, especially the higher ones, are themselves matters of exceeding beauty; and especially because I wish to show, not only that use and beauty are compatible forms of worth, but that the more mathematics has been cultivated for the sake of its inner charm, the fitter has it become for external service.

Having thus at the outset put himself in proper light and given his auditors a scholar's warning against what would else, he fears, foster a disproportionment of values, what will he go on to signalize among the utilities of a science whose primary allegiance to logical rectitude allies it to art, and which only incidentally and secondarily shapes itself to the ends of instrumental service? He knows that the applications of mathematics, if one will but trace them out in their multifarious ramifications, are as many-sided as the industries and as manifold as the sciences of men, penetrating everywhere throughout the full round of life. What will he select? He will not dwell long upon its homely uses in the rude computations and mensurations of counting-house and shop and factory and field, for this indispensable yet humble manner of world-wide and perpetual service is known of all men and women. He will quickly pass to higher considerations—to navigation, to the designing of ships, to the surveying of lands and seas, and the charting of the world, to the construction of reservoirs and aqueducts, canals, tunnels and railroads, to the modern miracles of the marine cable, the telegraph, the telephone, to the multiform achievements of every manner of modern engineering, civil, mechanical, mining, electrical, by which, through the advancing conquest of land and sea and air and space and time, the conveniences and the prowess of man have been multiplied a billionfold. It need not

be said that not all this has been done by mathematics alone. Far from it. It is, of course, the joint achievement of many sciences and arts, but—and just this is the point—the contributions of mathematics to the great work, direct and indirect, have been indispensable. And it will require no great skill in our speaker to show to his audience, if it have a little imagination, that, as I have said elsewhere, if all these mathematical contributions were by some strange spiritual cataclysm to be suddenly withdrawn, the life and body of industry and commerce would suddenly collapse as by a paralytic stroke, the now splendid outer tokens of material civilization would quickly perish, and the face of our planet would at once assume the aspect of a ruined and bankrupt world. For such is the amazing utility, such the wealth of by-products, if you please, that come from a science and art that owes its life, its continuity and its power to man's love of intellectual harmony and pleads its inner charm as its sole appropriate justification. Indeed it appears—contrary to popular belief—that in our world there is nothing else quite so practical as the inspiration of a muse.

But this is not all nor nearly all to which our applied mathematician will wish to invite attention. It is only the beginning of it. Even if he does not allude to the quiet service continuously and everywhere rendered by mathematics in its rôle as a norm or standard or ideal in every field of thought whether exact or inexact, he will yet desire to instance forms and modes of application compared with which those we have mentioned, splendid and impressive as they are, are meager and mean. For those we have mentioned are but the more obvious applications—those, namely, that continually announce themselves to our senses everywhere in the affairs, both great

and small, of the workaday world. But the really great applications of mathematics—those which, rightly understood, best of all demonstrate the human significance of the science—are not thus obvious; they do not, like the others, proclaim themselves in the form of visible facilities and visible expedients everywhere in the offices, the shops, and the highways of commerce and industry; they are, on the contrary, almost as abstract and esoteric as mathematics itself, for they are the uses and applications of this science in other sciences, especially in astronomy, in mechanics and in physics, but also and increasingly in the newer sciences of chemistry, geology, mineralogy, botany, zoology, economics, statistics and even psychology, not to mention the great science and art of architecture. In the matter of exhibiting the endless and intricate applications of mathematics to the natural sciences, applications ranging from the plainest facts of crystallography to the faint bearings of the kinetic theory of gases upon the constitution of the Milky Way, our speaker's task is quite as hopeless as we found the *pure* mathematician's to be; and he, too, will have to compromise; he will have to request his auditors to acquaint themselves at their leisure with the available literature of the subject and especially to read attentively the great work of John Theodore Merz dealing with the "History of European Thought in the Nineteenth Century," where they will find, in a form fit for the general reader, how central has been the rôle of mathematics in all the principal attempts of natural science to find a cosmos in the seeming chaos of the natural world. Another many-sided work that in this connection he may wish to commend as being in large part intelligible to men and women of general education and catholic mind is Enriques's "Problems of Science."



I turn now for a moment to the prospects of one who might choose to devote the hour to an exposition or an indication of modern developments in what it is customary to call the foundations of mathematics—to a characterization, that is, and estimate of that far-reaching and still advancing critical movement which has to do with the relations of the science, philosophically considered, to the sciences of logic and methodology. What can he say on this great theme that will be intelligible and edifying to the multitudes of men and women who, though mathematically inexperienced, yet have a genuine humane curiosity respecting even the profounder and subtler life and achievements of science? He can point out that mathematics, like all the other sciences, like the arts too, for that matter, and like philosophy, originates in the refining process of reflection upon the crude data of common sense; he can point out that this process has gradually yielded from out the raw material and still continues to yield more and more ideas of approximate perfection in the respects of precision and form; he can point out that such ideas, thus disentangled and trimmed of their native vagueness and indeterminateness, disclose their mutual relationships and so become amenable to the concatenative processes of logic; and he can point out that these polished ideas with their mutual relationships become the bases or the content of various branches of mathematics, which thus tower above common sense and appear to grow out of it and to stand upon it like trees or forests upon the earth. He will point out, however, that this appearance, like most other obvious appearances, is deceiving; he will, that is, point out that these upward-growing sciences or branches of science are found, in the light of further reflection, to be downward-growing as well, pushing their roots

deeper and deeper into a dark soil far beneath the ground of evident common sense; indeed, he will show that common sense is thus, in its relation to mathematics, but as a sense-litten mist enveloping only the mid-portion of the stately structure, which, like a towering mountain, at once ascends into the limpid ether far above the shining cloud and rests upon a base of subterranean rock far below; he will point out that, accordingly, mathematicians, in respect of temperamental interest, fall into two classes—the class of those who cultivate the upward-growing of the science, working thus in the upper regions of clearer light, and the class of those who devote themselves to exploring the deep-plunging roots of the science; and it is, he will say, to the critical activity of the latter class—the logicians and philosophers of mathematics—that we owe the discovery of what we are wont to call the foundations of mathematics—the great discovery, that is, of an immense mathematical *sub-structure*, which penetrates far beneath the stratum of common sense and of which many of even the greatest mathematicians of former times were not aware. But whilst such foundational research is in the main a modern phenomenon, it is by no means exclusively such; and to protect his auditors against a false perspective in this regard and the peril of an overweening pride in the achievements of their own time, our speaker may recommend to them the perusal of Thomas L. Heath's superb edition of Euclid's "Elements" where, especially in the first volume, they will be much edified to find, in the rich abundance of critical citation and commentary which the translator has there brought together, that the refined and elaborate logico-mathematical researches of our own time have been only a deepening and widening of the keen mathematical criticism of a few

centuries immediately preceding and following the great date of Euclid. Indeed but for that general declension of Greek spirit which Professor Gilbert Murray in his "Four Stages in Greek Religion" has happily characterized as "the failure of nerve," what we know as the modern critical movement in mathematics might well have come to its present culmination, so far at least as pure geometry is concerned, fifteen hundred or more years ago. It is a pity that the deeper and stabler things of science and the profounder spirit of man can not be here disclosed in a manner commensurate with the great exposition, surrounding us, of the manifold practical arts and industries of the world. It is a pity there is no means by which our speaker might, in a manner befitting the subject and the occasion, exhibit intelligibly to his fellow men and women the ways and results of the last hundred years of research into the groundwork of mathematical science and therewith the highly important modern developments in logic and the theory of knowledge. How astonished the beholders would be, how delighted, too, and proud to belong to a race capable of such patience and toil, of such disinterested devotion, of such intellectual finesse and depth of penetration. I can think of no other spectacle quite so impressive as the inner vision of all the manifold branches of rigorous thought seen to constitute one immense structure of autonomous doctrine reposing upon the spiritual basis of a few select ideas and, superior to the fading beauties of time and sense, shining there like a celestial city, in "the white radiance of eternity." That is the vision of mathematics that a student of its philosophy would, were it possible, present to his fellow men and women.

In view of the foregoing considerations it evidently is, I think, in the nature of the

case impossible to give an adequate sense of the human worth of mathematics if one choose to devote the hour to any one of the great aspects of it with which we have been thus far concerned. Neither the history of the subject nor its present estate nor its applications nor its logical foundations—no one of these themes lends itself well to the purpose of such an exposition, and still less do two or more of them combined. Even if such were not the case I should yet feel bound to pursue another course; for I have been long persuaded that, in respect of its human significance, mathematics invites to a point of view which, unless I am mistaken, has not been taken and held in former attempts at appreciation. I have already alluded to bearings of mathematics as distinguished from applications. It is with its bearings that I wish to deal. I mean its bearings upon the higher concerns of man as man—those interests, namely, which have impelled him to seek, over and above the needs of raiment and shelter and food, some inner adjustment of life to the poignant limitations of life in our world and which have thus drawn him to manifold forms of wisdom, not only to mathematics and natural sciences, but also to literature and philosophy, to religion and art, and theories of righteousness. What is the rôle of mathematics in this perpetual endeavor of the human spirit everywhere to win reconciliation of its dreams and aspirations with the baffling conditions and tragic facts of life and the world? What is its relation to the universal quest of man for some supreme and abiding good that shall assuage or annul the discords and tyrannies of time and limitation, withholding less and less, as time goes by, the freedom and the peace of an ideal harmony infinite and eternal?

In endeavoring to suggest, in the time remaining for this address, a partial answer



to that great question, in attempting, that is, to indicate the relations of mathematics to the supreme ideals of mankind, it will be necessary to seek a perspective point of view and to deal with large matters in a large way.

Of the countless variety of appetitions and aspirations that have given direction and aim to the energies of men and that, together with the constraining conditions of life in our world, have shaped the course and determined the issues of human history, it is doubtless not yet possible to attempt a confident and thoroughgoing classification according to the principle of relative dignity or that of relative strength. If, however, we ask whether, in the great throng of passional determinants of human thought and life, there is one supreme passion, one that in varying degrees of consciousness controls the rest, unifying the spiritual enterprises of our race in directing and converging them all upon a single sovereign aim, the answer, I believe, can not be doubtful: the activities and desires of mankind are indeed subject to such imperial direction and control. And if now we ask what the sovereign passion is, again the answer can hardly admit of question or doubt. In order to see even *a priori* what the answer must be, we have only to imagine a race of beings endowed with our human craving for stability, for freedom, and for perpetuity of life and its fleeting goods, we have only to fancy such a race flung, without equipment of knowledge or strength, into the depths of a treacherous universe of matter and force where they are tossed, buffeted and torn by the tumultuous onward-rushing flood of the cosmic stream, originating they know not whence and flowing they know not why nor whither, we have, I say, only to imagine *this*, sympathetically, which ought to be easy for us as men, and then to ask our-

selves what would *naturally* be the controlling passion and dominant enterprise of such a race—unless, indeed, we suppose it to become strangely enamored of distress or to be driven by despair to self-extinction. We humans require no Gotama nor Heraclitus to tell us that man's lot is cast in a world where naught abides. The universal impermanence of things, the inevitableness of decay, the mocking frustration of deepest yearnings and fondest dreams, all this has been keenly realized wherever men and women have had seeing eyes or been even a little touched with the malady of meditation, and everywhere in the literature of power is heard the cry of the mournful truth. "The life of man," said the Spirit of the Ocean, "passes by like a galloping horse, changing at every turn, at every hour."

"Great treasure halls hath Zeus in heaven,  
From whence to man strange dooms be given,  
Past hope or fear."

Such is the universal note. Whether we glance at the question in a measure *a priori*, as above, or look into the cravings of our own hearts, or survey the history of human emotion and thought, we shall find, I think, in each and all these ways, that human life owns the supremacy of one desire: it is the passion for emancipation, for release from life's limitations and the tyranny of change: it is our human passion for some ageless form of reality, some everlasting vantage-ground or rock to stand upon, some haven of refuge from the all-devouring transformations of the weltering sea. And so it is that our human aims, aspirations, and toils thus find their highest unity—their only intelligible unity—in the Spirit's quest of a stable world, in its endless search for some mode or form of reality that is at once infinite, changeless, eternal.

Does some one say: This may be granted,

but what is the point of it all? It is obviously true enough but what, pray, can be its bearing upon the matter in hand? What light does it throw upon the human significance of mathematics? The question is timely and just. The answer, which will grow in fullness and clarity as we proceed, may be at once begun.

How long our human ancestors, in remote ages, may have groped, as some of their descendants even now grope, among the things of *sense*, in the hope of finding *there* the desiderated good, we do not know—past time is long and the evolution of wisdom has been slow. We do know that, long before the beginnings of recorded history, superior men—advanced representatives of their kind—must have learned that the deliverance sought was not to be found among the objects of the *mobile* world, and so the spirit's quest passed from thence; passed from the realm of perception and sense to the realm of concept and reason: thought ceased, that is, to be merely the unconscious means of pursuit and became itself the quarry—mind had discovered mind; and there, in the realm of ideas, in the realm of spirit proper, in the world of reason or thought, the great search—far outrunning historic time—has been endlessly carried on, with varying fortunes, indeed, but without despair or breach of continuity, meanwhile multiplying its resources and assuming gradually, as the years and centuries have passed, the characters and forms of what we know today as philosophy and science and art. I have mentioned the passing of the quest from the realm of sense to the realm of conception: a most notable transition in the career of mind and especially significant for the view I am aiming to sketch. For thought, in thus becoming a conscious subject or object of thought, then began its destined course in reason: in ceasing to be

merely an unconscious means of pursuit and becoming itself the quarry, it definitely entered upon the arduous way that leads to the goal of rigor. And so it is evident that the way in question is not a private way; it does not belong exclusively to mathematics; it is public property; it is the highway of conceptual research. For it is a mistake to imagine that mathematics, in virtue of its reputed exactitude, is an insulated science, dwelling apart in isolation from other forms and modes of conceptual activity. It would be such, were its rigor absolute; for between a perfection and any approximation thereto, however close, there always remains an infinitude of steps. But the rigor of mathematics is not absolute—absolute rigor is an ideal, to be, like other ideals, aspired unto, forever approached, but never quite attained, for such attainment would mean that every possibility of error or indetermination, however slight, had been eliminated from idea, from symbol, and from argumentation. We know, however, that such elimination can never be complete, unless indeed the human mind shall one day lose its insatiable faculty for doubting. What, then, is the distinction of mathematics on the score of exactitude? Its distinction lies, not in the attainment of rigor absolute, but partly in its exceptional devotion thereto and especially in the advancement it has made along the endless path that leads towards that perfection. But, as I have already said, it must not be thought that mathematics is the sole traveler upon the way. It is important to see clearly that it is far from being thus a solitary enterprise. First, however, let us adjust our imagery to a better correspondence with the facts. I have spoken of *the* path. We know, however, that the paths are many, as many as the varieties of conceptual subject-matter, all of them converging towards the same high goal. We



see them originate here, there and yonder in the soil and haze of common thought; we see how indistinct they are at first—how ill-defined; we observe how they improve in that regard as the ideas involved grow clearer and clearer, more and more amenable to the use and governance of logic. At length, when thought, in its progress along any one of the many courses, has reached a high degree of refinement, precision and certitude, then and thereafter, but not before, we call it mathematical thought; it has undergone a long process of refining evolution and acquired at length the name of mathematics; it is not, however, the creature of its name; what is called mathematics has been long upon the way, owning at previous stages other designations—common sense, practical art perhaps, speculation, theology it may be, philosophy, natural science, or it may be for many a millenium no name at all. Is it, then, only a question of names? In a sense, yes: the ideal of thought is rigor; mathematics is the name that usage employs to designate, not attainment of the ideal, for it can not be attained, but its devoted pursuit and close approximation. But this is not the essence of the matter. The essence is that all thought, thought in all its stages, however rude, however refined, however named, owns the unity of being human: spiritual activities are one. Mathematics thus belongs to the great family of spiritual enterprises of man. These enterprises, all the members of the great family, however diverse in form, in modes of life, in methods of toil, in their progress along the way that leads towards logical rectitude, are alike children of one great passion. In genesis, in spirit and aspiration, in motive and aim, natural science, theology, philosophy, jurisprudence, religion and art are one with mathematics: they are all of them sprung from the hu-

man spirit's craving for invariant reality in a world of tragic change; they all of them aim at rescuing man from "the blind hurry of the universe from vanity to vanity": they seek cosmic stability—a world of abiding worth, where the broken promises of hope shall be healed and infinite aspiration shall cease to be mocked.

Such has been the universal and dominant aim and such are the cardinal forms that time has given its prosecution.

And now we must ask: What have been the fruits of the endless toil? What has the high emprise won? And what especially, have been the contributions of mathematics to the total gain? To recount the story of the spirit's quest for ageless forms of reality would be to tell afresh, from a new point of view, the history of human thought, so many and so diverse are the modes or aspects of being that men have found or fancied to be eternal. Edifying indeed would be the tale, but it is long, and the hour contracts. Even a meager delineation is hardly possible here. Yet we must not fail to glance at the endless array and to call, at least in part, the roll of major things. But where begin? Shall it be in theology? How memory responds to the magic word. "The past rises before us like a dream." As the long succession of the theological centuries passes by, what a marvelous pageant do they present of human ideals, contrivings and dreams, both rational and superrational. Alpha and Omega, the beginning and ending, which is, which was and which is to come; I Am That I Am; Father of lights with which is no variableness, neither shadow of turning; the bonitas, unitas, infinitas, immutabilitas of Deity; the undying principle of soul; the sublime hierarchy of immortal angels, terrific and precious, discoursed of by sages, commemorated by art, feared and loved by millions of men

and women and children: these things may suffice to remind us of the invariant forms of reality found or invented by theology in her age-long toil and passion to conquer the mutations of time by means of things eternal.

But theology's record is only an immense chapter of the vastly more inclusive annals of world-wide philosophic speculation running through the ages. If we turn to philosophy understood in the larger sense, if we ask what answers she has made in the long course of time to the question of what is eternal, so diverse and manifold are the voices heard across the centuries, from the East and from the West, that the combined response must needs seem to an unaccustomed ear like an infinite babel of tongues: the Confucian Way of Heaven; the mystic Tao, so much resembling fate, of Lao Tzu and Chuang Tzu; Buddhism's inexorable spiritual law of cause and effect and its everlasting extinction of individuality in Nirvana—the final blowing out of consciousness and character alike; Ahura Mazda, the holy One, of Zarathustra; Fate, especially in the Greek tragedies and Greek religion—the chain of causes in nature, "the compulsion in the way things grow," a fine thread running through the whole of existence and binding even the gods; the cosmic matter, or *το απειρον* of Anaximander; the cosmic order, the rhythm of events, the logos or reason or nous, of Heraclitus; the finite, space-filling sphere, or One, of the deep Parmenides; the four material and two psychic, six eternal, elements, of Empedocles; the infinitude of everlasting mind-moved simple substances of Anaxagoras; the infinite multitude and endless variety of invariant "seeds of things" of Leucippus, Democritus, Epicurus and Lucretius, together with their doctrines of absolute void and the conservations of mass and mo-

tion and infinite room or space; Plato's eternal world of pure ideas; the great Cosmic Year of a thousand thinkers, rolling in vast endlessly repeated cycles on the beginningless, endless course of time from eternity to eternity; the changeless thought-forms of Zeno, Gorgias and Aristotle; Leibnitz's indestructible, preestablished harmony; Spinoza's infinite unalterable substance; the Absolute of the Hegelian school; and so on and on far beyond the limits of practicable enumeration. This somewhat random partial list of things will serve to recall and to represent the enormous motley crowd of answers that the ages of philosophic speculation have made to the supreme inquiry of the human spirit: what is there that survives the mutations of time, abiding unchanged despite the whirling flux of life and the world?

And now, in the interest of further representing salient features in a large perspective view, let me next ask what contribution to the solution of the great problem has been made by jurisprudence. Jurisprudence is no doubt at once a branch of philosophy and a branch of science, but it has an interest, a direction and a character of its own. And for the sake of due emphasis it will be well worth while to remind ourselves specifically of the half-forgotten fact that, in its quest for justice and order among men, jurisprudence long ago found an answer to our oft-stated riddle of the world, an answer which, though but a partial one, yet satisfied the greatest thinkers for many centuries, and which, owing to the inborn supernalizing proclivity of the human mind, still exercises sway over the thought of the great majority of mankind. I allude to the conception of *jus naturale* or *lex naturæ*, the doctrine that in the order of Nature there somehow exists a perfect, invariant, uni-



versally and eternally valid system or prototype of law over and above the imperfect laws and changeful politics of men—a conception and doctrine long familiar in the juristic thought of antiquity, dominating, for example, the Antigone of Sophocles, penetrating the Republic and the Laws of Plato, proclaimed by Demosthenes in the Oration on the Crown, becoming, largely through the Republic and the Laws of Cicero, the crowning conception of the imperial jurisprudence of Rome, and still holding sway, as I have said, except in the case of our doubting Thomases of the law, who virtually deny our world the existence of any perfection whatever because they can not, so to speak, feel it with the hand, as if they did not know that to suppose an ideal to be *thus* realized would be a flat contradiction in terms.

If we turn for a moment to art and enquire what has been *her* relation to the poignant riddle, shall we not thus be going too far afield? The answer is certainly no. *In æternitatem pingo*, said Zeuxis, the Greek painter. "The purpose of art," says John La Farge, "is commemoration." In these two sayings, one of them ancient, the other modern, we have, I think, the evident clue. They do but tell us that art, like the other great enterprises of man, springs from our spirit's coveting of worth that abides. Like theology, like philosophy, like jurisprudence, like natural science, too, as I mean to point out further, and like mathematics, art is born of the universal passion for the dignity of things eternal. Her quest, like theirs, has been a search for invariants, for goods that are everlasting. And what has she found? The answer is simple. "The idea of beauty in each species of being," said Joshua Reynolds, "is perfect, invariable, divine." We know that by a faculty of

imaginative, mystical, idealizing discernment there is revealed to us, amid the fleeting beauties of Time, the immobile presence of eternal beauty, immutable archetype and source of the grace and loveliness beheld in the shifting scenes of the flowing world of sense. Such, I take it, is art's contribution to our human release from the tyranny of change and the law of death.

And now what should be said of science? Not so brief and far less simple would be the task of characterizing or even enumerating the many things that in the great drama of modern science have been assigned the rôle of invariant forms of reality or eternal modes of being. It would be necessary to mention first of all, as most imposing of all, our modern form of the ancient doctrine of fate. I mean the reigning conception of our universe as an infinite machine—a powerful conception that more and more fascinates scientific minds even to the point of obsession and according to which it should be possible, were knowledge sufficiently advanced, to formulate, in a system of differential equations, the whole of cosmic history from eternity to eternity in minutest detail, not even excluding a skeptic's doubt whether such formulation be theoretically possible nor excluding the conviction, which some minds have, that the doctrine, regarded as an *ultimate* creed, is an abominable libel against the character of a world where the felt freedom of the human spirit is not an illusion. It would be necessary to mention—as next perhaps in order of impressiveness—another doctrine that is, curiously enough, vividly reminiscent of old-time fate. I allude this time to the doctrine of heredity, a tremendous conception, in accordance with which—as Professor W. B. Smith has said in his recent powerful address on "Push or Pull?"—

"the remotest past reaches out its skeletal fingers and grapples both present and future in its iron grip." And there is the conservation of energy and that of mass—both of them, again, doctrines prefigured in the thought of ancient Greece—and numerous other so-called natural laws, simple and complex, familiar and unfamiliar, all posing as permanent forms of reality—as natural invariants under the infinite system of cosmic transformations—and thus together constituting the enlarging contribution of natural science towards the slow vindication of a world that has seemed capricious, lawless and impermanent.

Such, then, is a conspectus, suggested rather than portrayed, of the results which the great allies of mathematics, operating through the ages, have achieved in their passionate endeavor to transcend the tragic vicissitudes and limitations of life in an "ever-growing and perishing" universe and to win at length the freedom, the dignity and the peace of a stable world where order and harmony reign and spiritual goods endure. If we are to arrive at a really just or worthy sense of the human significance of mathematics, it is in relation with those great results of her sister enterprises that the achievements of this science must be appraised. Immense indeed and high is the task of criticism as thus conceived. How diverse and manifold the doctrines to be evaluated, what depths to be plumbed, what heights to be scaled, how various the relationships and dignities to be assigned their rightful place in the hierarchy of values. In the presence of such a task what can we think or say in the remaining moments of the hour? If we have succeeded in setting the problem in its proper light and in indicating the sole eminence from which the matter may be rightly viewed, we ought perhaps

to be content with that as the issue of the hour, for it is worth while to sketch a worthy program of criticism even if time fails us to perform fully the task thus set. And yet I can not refrain from inviting you to imagine, before we close, a few at least of the things that one who essayed the great critique would submit to his auditors for mediation. And what do you imagine the guiding lines and major themes of his discourse would be?

I fancy he would say: The question before us, ladies and gentlemen, is not a question of weighing utilities nor of counting applications nor of measuring material gains; it is a question of human ideals together with the various means of pursuing them and the differing degrees of their approximation; we are occupied with a question of appreciation, with the problem of values. I am, he would say, addressing you as representatives of man, and in so doing, I am not regarding man as a mere practitioner, as a hewer of wood and drawer of water, as an animal content to serve the instincts for shelter and food and reproduction. I am contemplating him as a spiritual being, as a thinker, poet, dreamer, as a lover of knowledge and beauty and wisdom and the joy of harmony and light, responding to the lure of an ideal destiny, troubled by the mystery of a baffling world, conscious subject of tragedy, yearning for stable reality, for infinite freedom, for perpetuity and a thousand perfections of life. As representatives of such a being, you, he would say, and I, even if we be not ourselves producers of theology or philosophy or science or jurisprudence or art or mathematics, are nevertheless rightful inheritors of all this manifold wisdom of man. The question is: What is the inheritance worth? We are the heirs and we are to be the judges of the great responses that time has made to



the spiritual needs of humanity. What are the responses worth? What are their values, joint and several, absolute and relative? And what, especially, is the human worth of the response of mathematics? It is, he would say, not only our privilege, but, as educated individuals and especially as representatives of our race, it is our duty, to ponder the matter and reach, if we can, a right appraisal. For the proper study of mankind is man, and it is essential to remember that "*La vie de la science est la critique.*" I have, he would say, tried to make it clear that mathematics is not an isolated science. I have tried to show that it is not an antagonist, nor a rival, but is the comrade and ally of the other great forms of spiritual activity, all aiming at the same high end. I have reminded you of the principal answers made by these to the spiritual needs of man, and I do not, he would say, desire to underrate or belittle them. They are a precious inheritance. Many of them have not, indeed, stood the test of time; others will doubtless endure for aye; all of them, for a longer or shorter period, have softened the ways of life to millions of men and women. Neither do I desire, he would say, to exaggerate the contributions of mathematics to the spiritual weal of humanity. What I desire is a fair comparative estimate of its claims. "Truth is the beginning of every good thing, both to gods and men." I am asking you to compare, consider and judge for yourselves. The task is arduous and long.

There are, our critic would say, certain paramount considerations that every one in such an enterprise must weigh, and a few of them may, in the moments that remain, be passed in brief review. Consider, for example, our human craving for a world of stable reality. Where is it to be found? We know the answer of theology,

of philosophy, of natural science and the rest. We know, too, the answer of literature and general thought:

The cloud-capped towers, the gorgeous palaces,  
The solemn temples, the great globe itself,  
Yea, all which it inherit, shall dissolve,  
And, like the baseless fabric of this vision,  
Leave not a rock behind.

And now what, he would ask, is the answer of mathematics? The answer, he would have to say, is this: Transcending the flux of the sensuous universe, there exists a stable world of pure thought, a divinely ordered world of ideas, accessible to man, free from the mad dance of time, infinite and eternal.

Consider our human craving for freedom. Of freedom there are many kinds. Is it the freedom of limitless room, where our passion for outward expression, for externalization of thought, may attain its aim? It is to mathematics, our critic would say, that man is indebted for that priceless boon; for it is the cunning of this science that has at length contrived to release our long imprisoned thought from the old confines of our three-fold world of sense and opened to its wing the interminable skies of hyperspace. But if it be a more fundamental freedom that is meant, if it be freedom of thought proper—freedom, that is, for the creative activity of intellect—then again it is to mathematics that our faculties must look for the definition and a right estimate of their prerogatives and power. For, regarding this matter, we may indeed acquire elsewhere a suspicion or an inkling of the truth, but mathematics, and nothing else, is qualified to give us *knowledge* of the fact that our intellectual freedom is absolute save for a single limitation—the law of non-contradiction, the law of logical compatibility, the law of intellectual harmony—sole restriction imposed by "the nature of

things" or by logic or by the muses upon the creative activity of the human spirit.

Consider next, the critic might say, our human craving for a living sense of rapport and comradeship with a divine Being infinite and eternal. Except through the modern mathematical doctrine of infinity, there is, he would have to say, no rational way by which we may even approximate an understanding of the supernal attributes with which our faculty of idealization has clothed Deity—no way, except this, by which our human reason may gaze understandingly upon the downward-looking aspects of the overworld. But this is not all. I need not, he would say, remind you of the reverent saying attributed to Plato that "God is a geometrician." Who is so unfortunate as not to know something of the religious awe, the solace and the peace that come from cloistral contemplation of the purity and everlastingness of mathematical truth?

Mighty is the charm of those abstractions to a mind beset with images and haunted by himself.

"More frequently," says Wordsworth, speaking of geometry,

More frequently from the same source I drew  
A pleasure quiet and profound, a sense  
Of permanent and universal sway,  
And paramount belief; there, recognized  
A type, for finite natures, of the one  
Supreme Existence, the surpassing life  
Which to the boundaries of space and time,  
Of melancholy space and doleful time,  
Superior and incapable of change,  
Not touched by welterings of passion—is,  
And hath the name of God. Transcendent peace  
And silence did wait upon those thoughts  
That were a frequent comfort to my youth.

And so our spokesman, did time allow, might continue, inviting his auditors to consider the relations of mathematics to yet other great ideals of humanity—our human craving for rectitude of thought, for ideal justice, for dominion over the

energies and ways of the material universe, for imperishable beauty, for the dignity and peace of intellectual harmony. We know that in all such cases the issue of the great critique would be the same, and it is needless to pursue the matter further. The light is clear enough. Mathematics is, in many ways, the most precious response that the human spirit has made to the call of the infinite and eternal. It is man's best revelation of the "Deep Base of the World."

CASSIUS J. KEYSER

COLUMBIA UNIVERSITY

THE NATIONAL ACADEMY OF SCIENCES  
PRELIMINARY PROGRAM OF SCIENTIFIC PAPERS FOR  
THE AUTUMN MEETING, NOVEMBER 15-17

The National Academy of Sciences will hold its stated autumn meeting at the American Museum of Natural History, New York City, on November 15, 16 and 17. The council will meet at 4 P.M. on Monday, November 15. There will be a lecture on "The Problem of Aerial Transmission" by Professor M. I. Pupin, of Columbia University, at 8 P.M., followed by a reception in the museum. On Tuesday and Wednesday morning at 9:30 A.M. there will be business sessions of the academy, followed at 10:30 by public scientific sessions. On the afternoon of November 16, there will be four papers of general interest. On the afternoon of November 17, luncheon will be served at the New York Zoological Park, followed by a visit to the New York Botanical Garden and afternoon tea. There will be a dinner on the evening of November 16 at the Chemists' Club.

The preliminary program of scientific papers is as follows:

*The Nature of Cell Polarity*: EDWIN G. CONKLIN.

*Heredity of Stature*: CHAS. B. DAVENPORT.

*Parental Alcoholism and Mental Ability, a Comparative Study of Habit Formation in the White Rat*: E. C. MACDOWELL. (Introduced by CHARLES B. DAVENPORT.)

The purpose of this investigation is to compare the mental capabilities of rats whose parents were



alcoholic with those of rats of normal parentage. It is commonly claimed that in man, the children of alcoholics are less teachable than children of normals. However, the exceeding difficulty of obtaining genetically comparable controls in man makes the study of a lower animal, although vastly different psychologically, of great interest, since double first cousins—the closest relationship possible for such comparisons—can be used. The first criterion used for judging mental activity has been habit formation in a Watson puzzle box. The habit to be learned consists of a trip around behind the box, breaking an electric circuit and so opening the front door, and returning to the front, entering the box for the reward of food. The data recorded consist in the times required to open and enter the door of the puzzle box. Each rat has been given 225 trials; 145 rats have been employed in this training. The data, summarized in various ways, have been represented by graphs. Awaiting the results of a second set of training experiments of a different nature, which are being conducted as a check on the first method, no general conclusions are given and only provisional conclusions are drawn about the present work.

*Rôle of the Lymphocytes in Resistance to Cancer:*

JAMES B. MURPHY. (Introduced by JACQUES LOEB.)

*Experimental Observations on Certain Phenomena of Growth:* THOMAS B. OSBORNE and LAFAYETTE B. MENDEL.

The growth impulse, or capacity to grow, can be retained and exercised at periods far beyond the age at which growth ordinarily ceases. In the case of our experimental animals, albino rats, in which increment of body weight ordinarily ceases before the age of 300 days, resumption and completion of growth was readily obtained at an age of more than 550 days. It is now reasonable to ask whether the capacity to grow can ever be lost unless it is exercised. Even after *very prolonged* periods of suppression of growth, the animals can subsequently reach the *full size* characteristic of their species. In this respect there is no impairment of the individual. The satisfactory resumption of growth can be attained not only after stunting by underfeeding, but also after the cessation of growth which results when the diet contains proteins unsuitable for the synthetic processes of growth or is low in protein. Growth in the cases referred to is resumed at a rate normal for the size of the animal at the time. It need not be slow, and frequently it actually exceeds the usual progress. The size or age at which

the inhibition of growth is effected does not alter the capacity to resume growth. Even when the suppression of growth is attempted for very long periods at a very small size (body weight) the restoration may be adequate when a suitable diet is furnished. The procreative functions are not necessarily lost by prolonged failure to grow before the stage of development at which breeding is ordinarily possible. The period of growth may be greatly prolonged by inadequacies in the diet, so that growth becomes very slow without being completely inhibited. Though the time of reaching full size is thus greatly delayed, growth, as expressed by suitable body weight, can ultimately be completed even during the course of long-continued retardation. The methods of partially retarding or completely suppressing growth are too varied and unlike to permit final answers as yet regarding the outcome of all of the procedures of inhibition for the subsequent welfare of the individual. Our observations apply to the effects upon size and a few other incidental features mentioned. Although it is doubtful whether the fundamental features will be altered, far reaching dogmatic statements are scarcely justifiable until the experiments have been extended to include other factors and animal species. A detailed account of the work will appear in an early issue of the *Journal of Biological Chemistry*.

*The Calorimeter as an Interpreter of the Life Processes:* GRAHAM LUSK.

The measurement of the heat production in fermentation of sugar by yeast cells indicates a height of cellular activity, approximating that possible in the cells of mammalian tissue as has been shown by Rubner. The basal heat production in an adult man is very closely proportional to the surface area, although the age of the organism also plays an important part in this regard. In only a very few conditions of disease is the heat production decidedly changed. Thus, in conditions such as fever and exophthalmic goiter there is a largely increased heat production. Fortunately the ingestion of food under these circumstances does not cause a greater heat production than such food would effect if given to a normal man. In all diseased conditions there is no departure from the manner of utilization of the important food stuffs, with the striking exception of diabetes.

*Ultramicroscopic Study of the Fibrin-gel:* W. H. HOWELL.

The fibrin formed in the coagulation of blood has been described as consisting of a coarse net-

work of fibrils, but examination of the clot under the ultra-microscope demonstrates that it is deposited as a meshwork of needles or crystals, which are formed separately and subsequently cohere to make a firm gel. The traditional fibrin network must be considered as an artefact produced by mechanical stress. In diluted plasmas or in solutions of fibrinogen made to clot by the addition of thrombin, the process of formation of the needles can be followed to a certain extent. They develop by the aggregation of amicros to form visible particles which assume quickly the shape of short rods. These latter may exhibit at first very active movements, more abrupt and extensive than the ordinary Brownian movements. The minute rods lengthen into needles presumably by accretion, although the actual process can not be followed. The retraction of the clot is one of its characteristic properties and must be referred to a slow condensation of the needles due to a closer aggregation of the particles. A moderate concentration in hydroxyl-ions in the fibrinogen solutions or plasmas increases the degrees of dispersion of the colloidal particles, and in this condition the addition of thrombin causes the formation of a gel of an entirely different character. This gel is non-retractile and under the ultra-microscope reveals no visible structure. Neutralization or slight acidification, insufficient to precipitate the fibrinogen, restores the property of giving fibrin-needles by interaction with thrombin. With the exception of the gels of the sodium salts of the fatty acids described by Zsigmondy, fibrin is the only gel formed by an emulsion colloid which exhibits clearly a vectorial or crystalline structure. As far as the observations have been carried, this peculiar characteristic is exhibited by the blood of all the vertebrates. In the blood of invertebrates (crustacea), a different gel is formed in clotting.

*Origin of the Flight of Birds:* C. WILLIAM BEEBE.  
(Introduced by HENRY FAIRFIELD OSBORN.)

Mr. Beebe has discovered both in the young of living birds and in *Archæopteryx* a series of powerful flight feathers on the hind limb, which he will demonstrate in support of a new theory of the origin of the flight of birds.

*Ornithological Survey of the Andes and Western Coast of South America:* FRANK M. CHAPMAN.  
(Introduced by HENRY FAIRFIELD OSBORN.)

The ornithological survey of the west coast of South America and of the Andes is now in its fourth year. It is organized along the lines which the United States Biological Survey has intro-

duced in this country. Dr. Chapman will present a *resumé* of the methods of exploration of the area already covered and of the principal results attained in regard to the origin and geographic distribution of the bird life of western South America.

*The Archegonium and Sporophyte of Treubia insignis* Goebel: DOUGLAS HOUGHTON CAMPBELL.  
(To be read by PROFESSOR COULTER.)

*Treubia* is a remarkably large liverwort discovered by Goebel in western Java. It has since been found in several widely separated regions. The writer discovered it on Mt. Banajao, Luzon, the only station yet reported for the Philippines. The material for the present paper was collected by the writer at the original station, Tjibodas, in western Java, in 1906. The archegonium differs from that of other liverworts in the increased number of rows of peripheral cells in the neck, there being always more than six. The young embryo has a large haustorium, much like that found in *Podomitrium* or *Pallaircinia*. The foot is not clearly delimited, and the differentiation of the sporogenous tissue takes place at a later period than is usual. No elaterophore is present, and no definite relation of spore mother-cells and elaters can be detected. The elaters finally become very long. A very massive calyptra is developed. The ripe capsule is ovoid in form, and opens by four somewhat irregular valves. *Treubia* probably is the nearest to the typical leafy liverworts (*Acrogynæ*), of any anacrogynous liverwort.

*Fossil Calcareous Algæ from the Panama Canal Zone, with Reference to Reef-building Algæ:* MARSHALL A. HOWE. (Introduced by N. L. BRITTON.)

After referring to the recent marked development of interest in the fossil calcareous algæ and the increasing recognition of their importance in the formation of limestones, the speaker will discuss in some detail certain Lithothamnienæ, collected in Pleistocene and Oligocene strata of the Panama Canal Zone by T. Wayland Vaughan and D. F. MacDonald, of the United States Geological Survey. Lantern slides will be shown illustrating the habit and microscopic structure of three species which are to be described as new. One of these, from the Pleistocene flats near Mt. Hope, the speaker considers to be represented also by living specimens found by him in the Colon region, only a few kilometers distant. The other two, from the Oligocene, perhaps find their nearest relatives in certain fossils from the Tertiary of Austria.



*Sterility in Plants and its Inheritance:* A. B. STOUT. (Introduced by N. L. BRITTON.)

The different types of sterility are discussed as a basis for the presentation of data on the phenomena of self and cross sterility involving physiological incompatibility. The evidence pertaining to the behavior and inheritance of this type of sterility in the flowering plants is summarized and original data presented giving the results of controlled self and cross pollinations with *Cichorium Intybus*, which involve nearly 500 plants and 125,000 individual flowers. The existence of self and cross sterility within this species is established, and the appearance of self-fertile plants is reported. Progenies of self-fertile plants have been studied into the third generation exhibiting with respect to self and cross sterility very irregular behavior and most sporadic inheritance.

*Recent Explorations in the Cactus Deserts of South America:* J. N. ROSE. (Introduced by N. L. BRITTON.)

The field work in connection with the cactus investigation of the Carnegie Institution of Washington contemplated a study of the deserts of not only North America but also of South America, the latter of which had never been thoroughly and consecutively explored. Two seasons have been given to South America, where an enormous amount of material has been gathered. The three following great deserts have been explored: First, the desert of western Argentina. This includes all of western Argentina. It resembles in its component parts the deserts of Arizona. Second, the desert of central Brazil. This is composed of the western parts of the states of Bahia and Pernambuco. It is very similar to the desert region of Santo Domingo, and the typical genera are nearly all West Indian. Third, the desert of Peru and Chile. This comprises all of western Peru and northern Chile. Its flora is the most distinct of any of the South American deserts.

*Some Factors Affecting the Inheritance Ratios in Shepherd's Purse:* GEO. H. SHULL. (Introduced by CHAS. B. DAVENPORT.)

*The Respiratory Ratio of Cacti in Relation to their Acidity:* HERBERT M. RICHARDS. (Introduced by R. A. HARPER.)

*Some Studies in Morphogenesis:* R. A. HARPER.

*Can We Observe Organic Evolution in Progress?* HERBERT S. JENNINGS.

*Orthogenesis in Plants:* JOHN M. COULTER.

The gymnosperms furnish the best illustrations among plants of what is called progressive evolution, or orthogenesis. Many lines of advance can be traced in unbroken series from the Devonian to the present time, involving structures that have been assumed to be beyond the influence of external conditions. Three such lines are used as illustrations. (1) *The Egg*.—In the history of gymnosperms there is a gradual shifting of the time of appearance of the egg in the ontogeny of the gametophyte. In the most primitive forms the eggs appear at the full maturity of the gametophyte. An unbroken series can be traced, representing an earlier appearance of eggs, extending from full maturity of the gametophyte, to very early embryonic stages. Experimental work upon sexuality in plants has shown that the appearance of gametes is in response to certain conditions of metabolism, and these conditions are associated with minimum vegetative activity. Any change of conditions shortening the period of vegetative activity would thereby hasten the appearance of eggs in the ontogeny of the gametophyte. This is exactly the result that, in the case of gymnosperms, would follow the differentiation of the year into definite seasons. The conclusion is that orthogenesis in this case holds some relation to the evolution of climate. (2) *The Proembryo*.—A similar illustration of progressive evolution is offered by the earlier and earlier appearance of wall-formation in the development of the proembryo, until the stage of free nuclei is eliminated. Since the progressive changes in the appearance of eggs and the development of the proembryo in general proceed *pari passu*, the inference is that they are both responsive to the same changing conditions. (3) *The Cotyledons*.—Recent work has shown that the number of cotyledons is also a response to conditions affecting vegetative activity. Among the causes that determine the progress from polycotyledony or dicotyledony to monocotyledony, a conspicuous one is the rate of growth of the subsequent members of the embryo, and this rate is a response to conditions for vegetative activity. The general conclusion is that the phenomenon of orthogenesis among plants is to be explained, not as the result of an "inherited tendency," but as a continuous response to progressive changes in the conditions of vegetative activity.

*Investigations Recently Conducted in the Wolcott Gibbs Memorial Laboratory:* THEODORE W. RICHARDS.

*The Life of Radium:* B. B. BOLTWOOD.

*Experiments and Theory of Conical Horns; Instruments for Measurements of Sound; An Instrument for Finding the Direction of a Fog-signal:* A. G. WEBSTER.

*The Biography of Alfred Marshall Mayer:* ALFRED G. MAYER and ROBERT S. WOODWARD.

*The Solar Radiation and its Variability:* G. C. ABBOT.

*The New Draper Catalogue:* EDWARD C. PICKERING.

One of the largest pieces of routine work undertaken at the Harvard College Observatory is the New Draper Catalogue. Its object, primarily, is to furnish the class of spectrum of all the stars so far as they can be determined from existing photographs. This classification was undertaken by Miss Annie J. Cannon, in October, 1911, and, by observations persistently maintained for four years, this portion of the work was practically completed, September 30, 1915. During this period, she classified 233,050 spectra, thus covering the entire sky. Meanwhile, 196,768 of these stars have been identified, and 194,820 of them entered in the card catalogue. The entire work will fill nine of the quarto volumes of *Annals* of the observatory, and will also give photometric and photographic magnitudes of all the stars on a uniform scale.

*On the Albedo of the Moon and Planets:* HENRY NORRIS RUSSELL. (Introduced by EDWARD C. PICKERING.)

*A Possible Origin for Some Spiral Nebulae:* GEORGE F. BECKER.

The paper seeks to show that the spiral,  $r^2\phi^2 = \text{constant}$ , is of use in interpreting the phenomena.

*Concomitant Changes in the Earth's Magnetism and Solar Radiation:* L. A. BAUER. (Introduced by R. S. WOODWARD.)

The author's preliminary conclusions respecting appreciable changes in the earth's magnetic state, concomitant with changes in the intensity of solar radiation as shown by Abbot's solar-constant values, are confirmed by a fresh investigation based upon solar and magnetic data for 1913 and 1914. It is found, for example, that decreased solar constant is accompanied by an increase in the constant used to define, at any time, the earth's magnetic state, and by a decrease in the range of the diurnal variation of the earth's magnetism. The numerical relationship between changes in solar constant and magnetic constant, or in the magnetic diurnal range, is shown to be sufficiently definite to strengthen the conclusions reached by Abbot respecting the sun's variability.

Diagrams were exhibited showing how, with the aid of the relation found, certain puzzling features respecting the secular variation of the earth's magnetism and its so-called "non-cyclic daily change," may be readily explained.

*Experiments on the Mean Free Path of Gases: Observations on Wood's One-dimensional Gas:* FRED E. WRIGHT and J. C. HOSTETTER. (Introduced by ARTHUR L. DAY.)

In a paper on "One-dimensional Gases and the Experimental Determination of the Law of Reflection for Gas Molecules," presented before this academy at its April meeting, Professor R. W. Wood directed attention to interesting phenomena which he ascribed to reflection of mercury atoms from an optically plane glass surface. Inspired by this paper it occurred to us to apply Wood's method to crystal plates and to ascertain if the crystal symmetry affects the distribution of the reflected mercury atoms. The experiments, with the exception of two which yielded no results of value, were all performed during the month of May, but the publication of the results has been postponed for reasons beyond our control. Our preliminary results led at once to the construction of a new piece of apparatus by means of which evidence was obtained proving that a large part of the phenomena are to be explained on the basis of the kinetic theory of gases; they show that in high vacua of pressures of only 0.2 bar there is still sufficient gas present to inhibit the formation of "one-dimensional gas." The experiments illustrate, moreover, the change, with pressure, of the mean free path of a given gas. Computations on the basis of the kinetic theory are in agreement with the experimental evidence and serve also to explain the clear zonal ring of no reflection observed both by Wood and by us.

*The Water Correction in Conductivity Determinations:* JAMES KENDALL. (Introduced by ALEXANDER SMITH.)

Conductivity water, however carefully prepared, can not be kept for more than a few minutes in contact with air without its specific conductivity rising to about  $0.9 \times 10^{-6}$  reciprocal ohms at 25° C. This is the same as the calculated specific conductivity of water saturated with carbon dioxide under its atmospheric partial pressure (3.69 parts in 10,000). It is therefore possible to eliminate entirely the influence of the water in exact conductivity measurements by correction for dissolved carbonic acid. This has been done for very dilute solutions of strong electrolytes (Arrhenius), transition electrolytes (Kendall), and weak elec-



trolytes (Walker and Kendall). The results in all cases confirm the assumption that the correction thus applied is valid and complete.

*Extremes of Adaptation in Carnivorous Dinosaurs, Tyrannosaurs and Ornithomimus*: HENRY FAIRFIELD OSBORN.

Complete skeletons of two of the most remarkable types of carnivorous dinosaurs, *Tyrannosaurus* and *Ornithomimus*, are mounted and exhibited especially at this meeting of the academy. Dr. Osborn will describe the two extremes of carnivorous dinosaur adaptation which they respectively represent.

*Influence of Certain Minerals on the Development of Schists and Gneisses*: C. K. LEITH. (Introduced by C. R. VAN HISE.)

A brief account of the development of quantitative methods in the study of the metamorphic cycle, leading up to a consideration of the formation of schists and gneisses. Evidence is presented to show that the development of schists and gneisses means convergence to a few mineral types, and that the characteristics of a few minerals determine to a large extent the course of chemical, mineralogical and textural changes in dynamic metamorphism.

*Sculpture of the Mission Range, Montana*: W. M. DAVIS.

The Mission Range, one of the smaller members of the Rocky Mountains in western Montana, composed of deformed rocks, chiefly quartzites, has the appearance of a tilted and dissected fault block, trending north and south, about 70 miles in length. The steeper face, probably representing the battered fault scarp, looks to the west. The low northern crest of the range emerges from the glacial deposits that floor the surrounding intermont depression at an altitude of 3,000 feet, and rises slowly southward with moderate undulation to an altitude of 9,500 feet near its abrupt southern end. The eastern side of the range is said to slope more gently than the steep western face. The present features of the range due to erosion since uplift, as seen from the intermont depression on the west, may be divided into three oblique belts by two nearly parallel south-dipping planes, about 1,000 feet apart. The middle belt has smoothly-rounded summits, and full-bodied, large-textured, waste-covered spurs of mature normal degradation between wide-spaced, steep-pitching, consequent valleys. The upper and southernmost belt includes, besides the rounded, waste-covered forms of normal erosion, bare-walled cirques and

troughs of local glaciation in more than a score of its high-reaching valleys; these features are best developed at the high southern end of the range, where the crest is locally sharpened into Alpine arêtes, and where the troughs, encroaching most broadly on the intervening spurs, reach down to the mountain base; at the middle of the range where its height is less, the cirques are faintly developed and the troughs extend only a few hundred feet down these valleys. The lower and northernmost belt shows many crags and knobs, cliffs and ledges, channels and hollows due to erosion by a broad and overwhelming glacier of Canadian origin. The northern half of this belt, or roughly, the northernmost fourth of the range, lies entirely beneath the slanting limit of Canadian glacial action, and is of disorderly form to its crest; the northernmost knobs, more or less detached from one another, rise hardly a hundred feet above the gravel plain: the southern half of the belt, in the second fourth of the range, preserves rounded normal forms along its crest and lower and lower down on its flanks as mid-range-length is approached; its valleys are barred across by morainic embankments along the slanting limit of the Canadian glacial action, and its spurs are imperfectly truncated in rugged facets which descend abruptly into Flathead lake. The height of the facets and the altitude of the embankments decrease southward; the facets become smaller and less continuous; the embankments become longer, larger and more continuous, until, curving away from the range base they unite in a noble terminal moraine, 400 or 500 feet in height and a mile or more in breadth, which swings westward across the intermont depression, separating Flathead lake on its northern concave side from the Mission plains of earlier glaciation on its southern, convex side. As far as I have seen and read, the Mission range is unique in its systematic tripartite arrangement of normal and glacial features.

*Crystallization of Quartz Veins*: WALDEMAR LINDGREN.

*The Minor Constituents of Meteorites*: GEORGE P. MERRILL. (Introduced by A. L. DAY.)

*A Peculiar Clay from near the City of Mexico*: E. W. HILGARD.

#### KARL EUGEN GUTHE

At the first meeting of the year the president of the Research Club of the University of Michigan read the following words of appreciation of the late Professor Guthe:

It is very fitting at this meeting, the first of the Research Club since the death of one of its specially honored members, Karl Eugen Guthe, that some words of appreciation should be spoken and I know well that in what I shall say now I shall have the hearty consent and sympathy of the whole club.

Sixteen years—1893 to 1903<sup>1</sup> and 1909 to 1915—a teacher in the university, nine years an active member of this club, and three years the dean of the graduate school, Dr. Guthe won for himself an unusually general and unusually cordial respect. His fine character, his high ideals, his constant loyalty to careful scholarship and scientific research made him a man whom it has been a benefit to us all to have known and to whom the university in its work as an educational institution and in its larger life, where the man as well as the teacher and officer makes himself felt, is indebted greatly.

It is pleasant to remember Dr. Guthe's last paper before the Research Club, read at the Roger Bacon memorial meeting in April, 1914; a paper on Bacon as a scientist that was a model of conscientious study and critical statement.

It is pleasant, too, to remember how seriously and faithfully he applied himself to the newly organized graduate school, seeking to put it and all its opportunities to the real service of productive study. What he accomplished, moreover, has given the school a most valuable foundation.

And, again, it is pleasant to remember in these days of national and racial differences, when so many are carried away by their partisan feeling, that although often at variance with the opinions and sympathies of many of his friends he neither gave offense to any nor took offense; and this, quite without sacrifice of his independence. He did indeed show, as too few have shown, how science and its methods, its ideals and its purposes, may give men integrity and poise; winning for himself and his views the respect that with his sense of fairness he was so ready to accord to others and to their views.

A true scholar, a faithful and efficient officer, and a most genial friend, Dr. Guthe was one whom we are glad to have had among us and whose memory we may well cherish.

#### SCIENTIFIC NOTES AND NEWS

A CABLEGRAM from Copenhagen to the daily papers, the correctness of which is open to

<sup>1</sup> 1903–1905 Dean Guthe was in the Bureau of Standards, Washington, D. C., and 1905–1909 he was professor of physics in the University of Iowa.

question, states that the Swedish government will award the Nobel prize in physics to Thomas A. Edison and Nikola Tesla; and in chemistry to Professor Theodor Svedberg.

PROFESSOR ADOLF VON BAEYER celebrated his eightieth birthday on October 31. With the beginning of the present semester he retired from the chair of chemistry at Munich in which he succeeded von Liebig in 1875.

PROFESSOR EDUARD BRÜCKNER has been elected president and Professor Eugen Oberhammer vice-president of the Vienna Geographical Society.

DR. DAVID W. CHEEVER, of Boston; Dr. Wilfred T. Grenfell, of Labrador; Dr. Stephen Smith, of New York; and Dr. Lewis McL. Tiffany, of Baltimore, were elected honorary fellows of the American College of Surgeons at its recent Boston meeting.

ON the occasion of the dedication of the Elizabeth Steel Magee Hospital the University of Pittsburgh conferred its doctorate of laws on Dr. John W. Williams, dean of the Johns Hopkins Medical School; Dr. Barton Cooke Hirst, professor of obstetrics, University of Pennsylvania; and on Dr. Walter William Chipman, professor of obstetrics and gynecology, McGill University.

PROFESSOR HENRY S. JACOBY, of the college of civil engineering, Cornell University, has been elected president of the Society for the Promotion of Engineering Education for the year 1915–16.

PROFESSOR A. H. WHITE has considered it necessary, owing to reasons of health, to resign the chair of pathology in the school of the Royal College of Surgeons in Ireland, which he has held for the last seventeen years.

DR. JOHN CASPER BRANNER, whose resignation of the presidency of Stanford University has been accepted to take effect December 31, will retire on a Carnegie pension and will continue to live on the Stanford campus. He will maintain an office in the university, in accordance with the trustees' invitation, and immediately after his retirement will be occupied for some time in a revision of two of his books, each of which is about to be published in a third edition—his Portuguese



grammar and his elementary text-book of geology, written in Portuguese for students of Brazil. In accepting Dr. Branner's resignation and appointing Dr. Ray Lyman Wilbur to succeed him, the Stanford board of trustees expressed "its obligation to Dr. Branner for his long and faithful service to the university and for his self-sacrifice in extending his term of service as president until December 31, 1915, at the urgent request of the board."

As an outcome of the recent Manchester meeting, the British Association has, as we learn from *Nature*, invited the following gentlemen to serve on a committee to consider and report upon the question of fuel economy (utilization of coal and smoke prevention), from a national point of view: Professor W. A. Bone, of the Imperial College of Science and Technology, London (chairman); Mr. E. D. Simon, chairman of the Manchester Air Pollution Committee (secretary); Professors P. P. Bedson (Armstrong College, Newcastle-on-Tyne), J. W. Cobb and J. B. Cohen (Leeds University), H. B. Dixon (Manchester University), Thomas Gray (Royal Technical College, Glasgow), H. S. Hele-Shaw (London), L. T. O'Shea and W. P. Wynne (Sheffield University), and Richard Threlfall (Birmingham), together with Dr. G. T. Beilby (Glasgow), Mr. Ernest Bury and Dr. J. E. Stead (Middlesbrough and the Cleveland district). The committee, which is empowered to add if necessary to its members, has been selected so as to include representative chemists, engineers and technologists from all the principal industrial areas.

At the third triennial conference of the National Association for the Study of Pellagra held in Columbia, S. C., October 21 and 22, the following officers were elected: president, Capt. Joseph F. Siler, M.C., U. S. Army; vice-presidents, P. A. Surg. R. M. Grimm, U. S. P. H. S., and Henry W. Rice, Columbia, S. C.; secretary, Dr. James W. Babcock, Columbia, S. C., and treasurer, Dr. James A. Hayne, Columbia, S. C.

THE Elisha Mitchell Society, University of North Carolina, elected in October the following officers for the ensuing year: James B.

Bullitt, president; T. F. Hickerson, vice-president; and J. E. Smith, secretary and treasurer.

DR. DAVID CHEEVER, of Boston, has been appointed chief surgeon in charge of the third Harvard surgical unit, which leaves this month for France. The unit consists of thirty-six nurses and eight surgeons in addition to Dr. Cheever.

ANOTHER party of American physicians returned to the United States on October 20 aboard the steamer *Cretic*. The members of this party who had been serving in Serbia were Dr. Louise Taylor-Jones, who established a hospital for babies at Nish; Dr. Thomas W. Jackson, of Washington, D. C., who succeeded Dr. Richard P. Strong as head of the American Sanitary Commission in Serbia; Dr. Joseph Thompson, of Cleveland, Ohio; and Dr. George W. Mellon, of Beaver, Pa., who will return to Belgrade after a three weeks' leave of absence in this country.

DR. HENRY A. STRECKER has been appointed chief medical inspector of the Philadelphia Bureau of Health, in succession to Dr. Charles A. Groff.

PROFESSOR HENRY LOUIS RIETZ, of the department of mathematics of the University of Illinois, has been appointed by Governor Dunne a member of the commission that is to investigate the operation of all pension laws heretofore enacted in the state. The commission is also to collect information from this country and foreign lands and is to make a report to the next general assembly.

HENRY B. STEER, a graduate of Cornell University in forestry, has received an appointment for forest work in the Indian Office, U. S. Department of the Interior. He will work on the eastern Cherokee lands in western North Carolina.

PROFESSOR LEONARD HEGNAUR has been appointed soils and crop specialist for field work under the direction of the extension department of the Washington State College.

MR. F. R. WULSIN is returning from Madagascar where he has been for about six months, collecting for the Zoological Museum, Harvard

University, after a long trip in British East Africa for the same purpose.

R. I. SMITH, formerly professor of entomology in the University of Porto Rico, College of Agriculture, Mayaguez, has been placed in charge of the Boston office for the foreign cotton quarantine, against the pink boll worm of Egypt and other countries.

DR. SAMUEL W. STRATTON, director of the United States Bureau of Standards, gave an illustrated lecture before the engineering students of the Ohio State University on November 5, on "The Work of the Bureau of Standards."

DR. WILLIAM S. FRANKLIN, recently professor of physics in Lehigh University, lectured before the students of Sibley College, Cornell University, on November 3, on "Some Mechanical Analogies in Electricity and Magnetism," with experiments. On November 5, at a meeting of the local section of the American Institute of Electrical Engineers, he gave a talk "On Electric Waves," with demonstrations and experiments.

PROFESSOR MARSTON TAYLOR BOGERT, of Columbia University, on October 25, addressed the staff and students of the school of chemistry of the University of Pittsburgh and of the Mellon Institute upon "Reminiscences of Famous European Chemists and Chemical Laboratories."

THE Swiney lectures on geology in connection with the British Museum (Natural History) will be delivered by Dr. J. D. Falconer, beginning November 13. There will be twelve lectures on "Ice and the Ice Age."

THE lectures before the Royal College of Physicians of London this autumn are as follows: The Bradshaw Lecture, by Dr. Mitchell Clarke, on November 2, the subject being nervous affections of the sixth and seventh decades of life; the FitzPatrick Lectures on November 4 and 9, by Dr. W. H. R. Rivers, on medicine, magic and religion; and the Goulstonian Lectures, by Dr. Gordon Holmes, on November 16, 18 and 23, on acute spinal lesions, with special reference to those of warfare.

BRIGADIER-GENERAL GEORGE M. STERNBERG, retired, surgeon-general of the army, from 1893 to 1902, distinguished for his investigations of yellow fever and other diseases, died at his home in Washington, on November 3, at the age of seventy-seven years.

WIRT TASSIN, formerly chief chemist and assistant curator of the division of mineralogy, U. S. National Museum, since 1908 a consulting metallurgist at Chester, Pa., known for his contribution to mineralogy and metallurgy, died on November 2, at the age of forty-six years.

DR. WILLIAM NOYES, for fifteen years superintendent of the Boston Insane Hospital, known for his work on neurology and psychiatry, died on October 20, at his home in Jamaica Plain, aged fifty-eight years.

FELIX LECONTE, professor in physical and mathematical sciences at the University of Ghent, died in London on October 11, aged fifty years.

As a result of the explorations of the Siberian expedition of the Museum of the University of Pennsylvania, the university will shortly be the possessor of a valuable collection of ethnological specimens from the primitive Tungus tribes in the arctic regions of Siberia, and the scientific world enriched by writings and data on a branch of the Mongolian race of which hitherto virtually nothing has been known. More than 700 miles were traveled by the explorers through a country almost without food and sometimes with a temperature as low as 80 degrees below zero. The University Museum's Amazon Expedition has forwarded an account of its discovery of the original habitat of the Mondurucus Indians, a little-known tribe of savages who behead their enemies and then boil the heads. Dr. William C. Farabee, who is in charge of the expedition, spent a long time among the Mundurucus, studying their language, their manners and customs and making a vocabulary and writing down much of their folk-lore, as a result of which he expects to settle absolutely the long vexed question of the relation of this tribe to the Tupi. He also visited villages of



the Apiacas and Manes and got important data.

IN connection with the twentieth anniversary celebration of the New York Botanical Garden, Miss Caroline Coventry Haynes presented to the Garden the collection of Hepaticæ formerly belonging to Dr. Marshall A. Howe, from whom she purchased it in 1909. This collection is especially rich in Californian material and includes most of the specimens described or cited by Dr. Howe in his memoir on "The Hepaticæ and Anthocerotæ of California," published in 1899. The collection includes, besides, a considerable amount of foreign material received in exchanges with Schiffner, Levier, Heeg, and other European students of the Hepaticæ. The pockets of specimens now turned over to the Garden number 1,174. The Ricciaceæ of this herbarium had already been deposited at the Garden. Certain specimens belonging to groups in which Miss Haynes is especially interested are being retained by her for a time, making the total number of pockets of specimens that are eventually to come to the Garden about 1,851. The New York Botanical Garden has received also one thousand dollars from the executor of the will of Jacob Langeloth, and this legacy has, by order of the board of managers, been credited to the principal of the Endowment Fund for Science and Education, increasing this fund to \$76,455.

AMONG the resources of California of great potential value and as yet only slightly developed are the mineral springs which abound in many parts of the state. Streams of pure water issue in large volume from the northern lava fields, but some of the desert springs yield strong brines. Some mountain regions yield springs of ice-cold water in mid-summer, and in the same vicinity are pools of vigorously boiling water. Water so corrosive that clothing soon falls to pieces under its action is common in some localities; in others issue springs of hot, soft water excellent for laundry use. Several of the more noted springs are mere trickles of pleasant-tasting carbonated water; other and larger springs of more delicious natural "soda water" are at present re-

mote from roads and are known only to the hunter and prospector. Many springs form deposits of salt that are welcomed by cattle and wild animals as "deer licks"; others are a menace to small life because of the purgative salts they contain or of the great amount of carbonic-acid gas they give off. The chemical constituents produce notable coloring in many waters, giving in some springs shades of yellow, green or blue, and at one place a milky and an inky-black stream issue side by side. In connection with studies of other phases of the water resources of California G. A. Waring, of the United States Geological Survey, made an examination of the springs, and the results are embodied in Water-supply Paper 338. Of the 600 springs described in this paper, more than 100 are used to greater or less extent as resorts, but only about one third of this number have been patronized primarily for the curative value of their waters, the others being noted chiefly as pleasure resorts. At a few, however, equipment comparable with that of the well-known European spas is in use and advanced practise in therapeutic treatment is employed.

RUBBER manufacture involves the use of numerous poisonous substances, of which lead salts, antimony pentasulphide, aniline oil, carbon disulphide and carbon tetrachloride are the most dangerous. The operations involving exposure to these poisons, however, employ but a small proportion of the large number of workers. No women and very few boys are engaged in such operations. A lesser danger is found in the use of coal-tar benzol and of various petroleum products, such as naphtha, benzine, etc. A considerable number of the workers, including women and boys, are exposed to the fumes of these compounds. These facts are brought out in an investigation by Dr. Alice Hamilton of the industrial poisons used in the rubber industry, the results of which have just been published as Bulletin 179 of the Bureau of Labor Statistics of the Department of Labor. While it was impossible to get complete data as to the frequency of industrial poisoning in the rubber industry, records were secured of no less than 66 cases

of lead poisoning which occurred in 1914 among the rubber workers in the United States. Cases were also found of naphtha poisoning, and of poisoning from carbon disulphide, carbon tetrachloride and aniline oil. The dangerous nature of some of the compounds used in the rubber industry is not as yet commonly known, so that cases of industrial poisoning may occur without being recognized as such and ascribed to their true cause. Also, in the case of some of the compounds, the symptoms of poisoning may be obscure or may not develop until some time after the exposure has taken place, so that again the resulting harm may not be ascribed to its true cause. The investigation on which the bureau's report is based covered 35 rubber factories, located in fifteen cities or towns in nine states. Practically every branch of the rubber industry was included among the activities of these factories. The processes of rubber manufacturing are many and various and there is a great difference in the extent to which men and women employed in the different branches are exposed to the danger of poisonous dusts and fumes.

#### UNIVERSITY AND EDUCATIONAL NEWS

By the will of the late A. F. Eno, his residuary estate, which may be very large, is bequeathed to Columbia University.

THE American Association of University Professors will hold its annual meeting in Washington, D. C., on Friday, December 31, 1915, and Saturday, January 1, 1916. Besides routine business, the principal matters to come before the association at this meeting will be the final adoption of the constitution, and the presentation and discussion of the general report and declaration of principles of the Committee on Academic Freedom and Tenure of Office.

PROFESSOR CORNELIUS BETTEN, formerly with Lake Forest College, Illinois, is now on the faculty of the New York State Agricultural College, Cornell University.

HERMAN J. MULLER, a student in the department of zoology of Columbia University, has

been appointed instructor in biology at the Rice Institute, Houston, Texas.

DR. GEORGE VON PULLINGER DAVIS has gone to Salt Lake City as professor of physiology in the University of Utah.

DR. LEO LOEB has been appointed professor of comparative pathology in the medical school of Washington University.

#### DISCUSSION AND CORRESPONDENCE

##### THE POSITION OF REFERENCES IN JOURNAL ARTICLES

TO THE EDITOR OF SCIENCE: The subject of Mr. Heyward Scudder's letter in SCIENCE for October 1 (p. 454) is one that has long interested me as author, as editor and as secretary of the British Association Committee on Zoological Bibliography and Publication. I therefore venture a few comments on his proposals.

It happens that I have just had to see through the press an article furnished with references in the precise manner desired by Mr. Scudder. The article, however, was so long that it had to be spread over three monthly parts of the periodical to which it was sent. Thus, on the proposed plan, the reader of the first two parts would have to wait one or two months for the references—a course that was quite inadmissible. This illustrates one frequent objection to the proposals. Mr. Scudder himself admits others, even when the article is less lengthy.

There are two sets of people to be considered: on the one hand, the editor and publisher; on the other, the author and his readers. Mr. Scudder's main argument is the saving to the former, but the utmost saving that he claims does not amount to one per cent., and the average of all his actual instances shows a less saving than half a page in a hundred. That amounts to 31 sheets in an edition of 1,000 in octavo. The total pecuniary saving from the paper bill and the printer's bill would thus be about two dollars, which equals one fifth of a cent per copy. The more important journals, which begin each article on a fresh page, would rarely effect any saving in paper.



This trivial saving may, I venture to think, be disregarded, and the question decided purely in the interests of the reader. Now the reader wants one or all of three things: first, a speedy reference from the quoted statement to the authority; secondly, a name and a date that will appeal at once to his historical sense and furnish him with some idea of the present value of the statement; thirdly, a conspectus of the so-called "literature" arranged in some logical order. Whatever the merits of Mr. Scudder's proposals, they provide the reader with none of these things. Their merits are twofold: they get rid of references at the foot, which are expensive and encourage the vicious habit of putting matter into footnotes because the author will not be at the pains to rehandle his text; and they do away with *loc. cit.*, which is not merely wasteful, but more often than not erroneously used in place of *op. cit.* or *tom. cit.*

In offering counter-proposals it is advisable to distinguish between two classes of papers: first, brief articles in which the references are correspondingly few and rarely repeated; secondly, long articles or memoirs in which the references are correspondingly numerous and frequently repeated. In articles of the first class, references may quite easily be worked into the text, and can be repeated by giving the cited author's name, with a distinguishing date when more than one of his works has been mentioned. For memoirs of the second class it is certainly convenient for both author and reader to have a "list of works referred to" at the end (or sometimes at the beginning) of the memoir. But though it may save trouble to the author to number these works in the order of their citation, this will save nothing to the reader, for that order has often no meaning apart from the text. Here is an actual example: 1. Tegner, 1880. 2. Jespersen, 1913. 3. Johannsen, 1913. 4. Anon., no date. 5. Höffding, 1910. 6. Höffding, 1914. 7. Goethe, 1858. 8. (Another page of 3.) 9. Anon., 1873. 10. Rádl, 1913. 11. Bernard, 1867, and so on for nearly 100 items. To use such a list as a guide, or to look up an author in it, is difficult enough as it is, but would be more so if the items were sepa-

rated only by a 5 mm. space (a mutton-head, as our printers call it). The most convenient plan for subsequent reference is to give the authors in alphabetical order, with the papers by each in chronological order. The references in the text will then be simply: TEGNER (1880), GOETHE (1858, p. 279), CLAUDE BERNARD (1867), H. M. BERNARD (1896, p. 53). Such a mode of reference gives the historical perspective, and is of itself enough to save a reader familiar with the subject from repeated application to the list at the end.

So far as I can see, the methods here outlined (which have no pretensions to novelty) would meet all Mr. Scudder's requirements and need not cost more in either time or money.

F. A. BATHER

BRITISH MUSEUM OF NATURAL HISTORY,  
LONDON, S.W.,  
October 13, 1915

IN a recent number of SCIENCE<sup>1</sup> Heyward Scudder, in an article with the above heading, calls attention to the fact that from one half to one per cent. of the space in the majority of scientific journals giving many references is wasted by the faulty position and arrangement of the references. He recommends, as a means of saving this space, that each reference be given a number (the numbers to run consecutively) and that all references be printed at the end of the article, leaving an extra wide spacing between the period at the end of one number and the next number, in order to catch the eye.

It is quite possible that the method suggested would effect a small saving in space. It would seem, however, that the desirability of this method of giving references is open to discussion.

It must be conceded at the outset that the matter is largely one of personal opinion, and that one of the hardest tasks of a conscientious editor is to edit consistently the references of his journal. Furthermore, no two journals, unless published under the same supervision, have the same system of references. Certainly no two papers, unless by the same author, will give references in exactly the same way and

<sup>1</sup> SCIENCE, 1915, XLII., 454, October 1.

even in the same paper one may find differences. Because of this it is not surprising that all of us do not agree with Scudder.

Our position is stated in the directions given for the "Placing of References" as found in *Bibliographic Style*, published by the American Medical Association.

All comments or bibliographic references (except footnotes that concern the article as a whole) on various matters mentioned in an article should be used as individual footnotes, numbered consecutively throughout the article, each to be placed at the foot of the required column (or page), rather than grouped at the end as a bibliography. The latter method may be followed, however, if an author desires merely to give a general survey of the literature on the subject. When the same reference is used twice, instead of duplicating the note or using the words "*loc. cit.*," it is better to repeat in the text the reference number of the original note.

References are given for the convenience of the reader. In general they are specific in character and the reader desires to consult them in connection with the particular point in question and not in a general way. It is more economical of time from the reader's point of view to have references at the foot of the page, where they may readily be consulted, than at the end of the article, which necessitates the turning of an indefinite number of pages every time a reference is needed. This is especially true in those cases where it is necessary to find a reference to a particular fact. One looks through the article in question until the desired point is found and then, by glancing at the foot of the page, at once finds the reference.

While this is a personal opinion the writer finds that it is shared by a number of his fellow-workers. If the method suggested by Scudder is as convenient as he would have us believe, it is surprising that more of the journals written by and for busy scientific men should not have adopted it. To our knowledge the only journal that consistently uses Scudder's method is the *Biochemical Journal*.<sup>2</sup> The journal recently founded by Dr. V. C.

<sup>2</sup> This journal uses a modified form, since a separate line is given for each reference.

Vaughan, *The Journal of Laboratory and Clinical Medicine*, apparently uses, in part at least, the same system of reference-giving in the original articles (it may be at the author's discretion), but uses the more convenient form of references at the foot of the page in the editorial section.

Another point made by Scudder in favor of grouping references at the end of the article is that this method assists one in looking up original references, in that it saves time in the long run. References are individual and are found in different magazines or in different volumes of the same magazine. In the interval between looking up two original articles it is just as easy, or easier, to turn a page or two to find the next numbered reference, as it is to locate one's place in a running paragraph of references, printed in eight-point or even in smaller type.

In this connection it may be permissible to call attention to one aspect of the question which would really effect a saving of time. Much annoyance and loss of time is caused by the inaccurate quotation of references. The degree of inaccuracy may be either a wrong page number, a wrong volume number, or a wrong journal. Sometimes the error is easily corrected, but more frequently it is not. Because it is so easy to make mistakes of this kind, it is only just to the reader that all references be carefully checked in the manuscript and verified in the galley proof. In very few cases does the journal publishing the article verify the reference, so the burden and the blame usually fall upon the author.

As a rule, journals are desirous of pleasing their contributors and readers and will print references as given. The question of saving one per cent. of the space would probably give way to the question of convenience to the reader. Since each contributor has the right to decide for himself, we have felt it worth while to emphasize the old way of giving references, as opposed to Scudder's modification, especially since it seems to be by far the better way.

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## INJECTIONS OF THE BUNDLE OF HIS

A SENSE of justice and the firm conviction that publicity can alone correct similar errors prompt me to speak in behalf of my former associate, Dr. Lhamon. The following statement is supplementary to a short foot-note accompanying a paper by M. R. King in the *American Journal of Anatomy* for 1916.

In August, 1911, my former teacher and colleague, Professor W. G. MacCallum, accompanied by Dr. K. M. Vogel, paid a friendly visit to my laboratory in the presence of my former colleague, Professor Zinsser. During this visit Professor MacCallum showed keen interest in, and appreciation of, some specimens of bovine and sheep hearts in which the sheath of the sino-ventricular bundle had been injected with India ink, etc., by my former associate, Dr. Lhamon. Dr. MacCallum inquired especially after the method of injection because he considered it of probable use in connection with demonstrations on pathological human hearts.

Under date of October 24, 1911, Dr. B. S. Oppenheimer, then fellow in pathology with Professor MacCallum, wrote me, saying:

Dr. MacCallum, in whose department I am doing heart work, told me that you had a method of demonstrating beautifully the auricular-ventricular system by injecting certain substances with a hypodermic syringe. It would save me a great deal of time if I could use such a method in my examination of pathological hearts, etc.

I replied to this letter, briefly explaining Dr. Lhamon's method, referred Dr. Oppenheimer to Dr. Lhamon, giving the latter's address, and added that Dr. Lhamon's article was to appear in the *American Journal of Anatomy*.

In the *Proceedings of the New York Pathological Society*, New Series, Vol. XI., Nos. 5 and 6, pages 130-132, 1911, Dr. Alfred Einstein Cohen, fellow in pathology with Professor MacCallum during 1910-11 and a friend and predecessor of Dr. Oppenheimer, is officially reported to have given a "demonstration of ox hearts showing injection of the conductive system." In discussing this paper Dr. Oppenheimer is officially reported as having said:

After hearing of the method through Dr. MacCallum I injected a few hearts of ungulates with India ink and water, etc. (*l. c.*, p. 131).

Since according to the official published reports Professor MacCallum was then president of the society he can no doubt testify to the accuracy of the facts reported there if these were in question.

In a personal letter written to me at his own initiative on January 5, 1915, Dr. Cohen admits responsibility for the publication of the above report, but pleads that he acknowledged Lhamon's priority—two years after having anticipated Lhamon's work by his own publication. Dr. Cohen further pleads that this report can not be regarded in the light of a publication, although the *Transactions of the New York Pathological Society* are published regularly, received by several libraries and are listed in the Index catalogue and the Index Medicus, etc. Dr. Cohen adds that hence "neither Dr. MacCallum nor I can be held responsible for an indiscretion."

Dr. Cohen also says in this letter that it is stated, furthermore, in Dr. Oppenheimer's discussion that both of us (Drs. Cohen and Oppenheimer) had heard of A-V. bundle from Dr. MacCallum.

As a matter of fact Dr. Oppenheimer is officially reported as having said that

After hearing of this method through Dr. MacCallum I (not we, as Dr. Cohen would have it), injected a few hearts of ungulates with India ink diluted with water, etc." (*l. c.*, p. 131).

Although Dr. Cohen frankly admits having heard of Dr. Lhamon's work and stated in a personal letter written four years later "that so far as priority is concerned not only I but every one acquainted with the subject gives and has given full credit to Lhamon" he nevertheless claims "that an injection of the right side of the heart was made and published for the first time by me." This false claim was made by Dr. Cohen in 1915 in spite of the fact that Lhamon three years before (*Am. Jr. Anat.*, Vol. 13, 1912, p. 63) stated that "with the sheath system in the right ventricle similar results were obtained, etc." That is,

Dr. Cohen frankly admits that he heard of Lhamon's work and that Dr. Lhamon is given priority by everybody including himself and then claims priority for himself for the right side of the heart! As a matter of fact Lhamon's specimens showing injections on both sides, which are still in this laboratory, and which were described in his paper, were made over half a year before Dr. Cohen heard of how they were made through Drs. MacCallum and Oppenheimer.

Dr. Lhamon's manuscript on "The Sheath of the Sino-ventricular Bundle" which is still on file, was finished on July 22, 1911, and officially accepted for publication in the *American Journal of Anatomy* on November 3 of the same year. Because Dr. Lhamon had left the United States to accept an assistant professorship in the Philippine Medical School in August, 1911, a clerical error in the address caused a delay of several months in the return of the manuscript to the publishers. Hence the article did not appear till March, 1912, three months after Dr. Cohen's publication.

It is significant that there also is internal evidence in Dr. Cohen's report and in Dr. Oppenheimer's discussion which clearly betrays the origin of their ideas. But comment upon this is unnecessary and I make this statement of the facts only in the interests of truth and in justice to Dr. Lhamon and this laboratory.

A. W. MEYER

STANFORD UNIVERSITY,  
September 20, 1915

#### THE PISTILLATE SPIKELET IN *ZEa* MAYS

HUNT<sup>1</sup> makes the statement that in the pistillate spikelet in *Zea Mays*, each spikelet is two flowered, the lower one being abortive. Our most recent work on the grasses, by Hitchcock<sup>2</sup> contains a similar statement, as do all of the other botanical text-books examined which treat of this subject. The prevailing idea seems to be that the pistillate spikelet in this species never contains more than one well-developed flower.

<sup>1</sup> "Cereals in America," p. 147, Orange Judd Company, 1904.

<sup>2</sup> "A Text-book of Grasses," p. 161, The Macmillan Company, 1914.

I had occasion some time ago to prepare material of corn spikelets for a class in systematic botany, and as I was growing the Country Gentleman variety of corn in my garden at the time, I used this. I was unable, however, to find any indication of the sterile flower in many of the spikelets, which led to closer observation. I soon discovered that some of the spikelets had two well-developed flowers inside each pair of glumes, and that others had but one such flower and another one partially developed. All gradations occurred in the same ear between spikelets with but one well-developed flower and those which had two.

Those who are familiar with this variety of corn will probably remember that the grains are irregularly arranged on the cob in many places, and that they do not always occur in regular rows as is commonly the case in corn. This irregularity is probably due to the fact that the development of the second flower in many of the spikelets tends to throw some of the grains out of alignment.

ALBAN STEWART

UNIVERSITY OF WISCONSIN

#### A REMARKABLE FLIGHT OF CADDIS FLIES AND CHIRONOMIDS

ON the evening of September 8, 1909, while the writer was crossing the upper part of Currituck Sound, N. C., the air seemed filled with flying insects. They were so numerous over the water that vision was restricted to a much shorter radius than usual. The constant impacts of the insects against the face became annoying, the more so that they maintained their frequency throughout the six-mile sail across the sound.

Early the next morning I boarded the small steamer *Comet*, which had come from many miles down the Sound during the night. On this boat there was plentiful evidence of the swarm of insects. There was a layer of insects between the glass cover and the poster, concealing the print in every one of the framed shipping regulations and notices of various kinds about the steamer. How the



little creatures crowded into such small spaces is a marvel, but it is proof also of the extreme abundance and all-pervading character of the swarm.

The large lamp in the cabin, with a chimney of a capacity of perhaps a gallon, I was told, had been snuffed several times by the crowding insects. On a spread newspaper nearby lay a pile of the insects which had been dumped from the chimney. There were fully enough to have completely filled the chimney—an innumerable mass. From this collection I gathered some specimens for identification. The Chironomids, which were largely in the majority, have been identified by J. R. Malloch as *Chironomous halteralis* Coquillett, *C. modestus* Say, and *Tanytarsus* sp. The Trichoptera identified by Nathan Banks are *Ecetina incerta* Walker, and *Oxyethira dorsalis* Banks. No representatives of other orders were noted.

W. L. McATEE

#### ON THE NOMENCLATURE OF ELECTRICAL UNITS

THE present cumbrous method of describing the electrical units in the electrostatic and electromagnetic systems suggests the advisability of the adoption of an abbreviated nomenclature which, while being simple, may be sufficiently descriptive. An attempt in this direction has been made by Messrs. Franklin and MacNutt in their text-book "The Elements of Electricity and Magnetism." In it "ab," the first syllable of the word "absolute," is prefixed to the names of the practical units to designate the corresponding units of the electromagnetic system. It appears to the writer that a similar abbreviation might with advantage be employed in the case of the electrostatic system, and he suggests the use of the prefix "es" for the electrostatic system and, possibly, the use of the prefix "em" instead of "ab" for the electromagnetic system. Thus the elementary charge of electricity would no longer be described as " $4.7 \times 10^{-10}$  electrostatic units of quantity (or charge)," but as " $4.7 \times 10^{-10}$  escoulombs." Similarly, the ratio of electronic charge to mass would not be expressed as " $1.7 \times 10^7$  electromagnetic units of

quantity (or charge) per gram," but as " $1.7 \times 10^7$  emcoulombs per gram." Certain written abbreviations naturally follow, thus: esc = escoulomb, emc = emcoulomb, esa = es-ampere, and so on. This system of nomenclature may be extended to the so-called "rational systems" by using "res" instead of "es" and "rem" instead of "em."

It is hoped that the use of some abbreviated system of nomenclature may become common, and the foregoing is offered as a possible contribution toward that end.

A. E. CASWELL

UNIVERSITY OF OREGON,

October 14, 1915

#### COOPERATION IN LABELLING MUSEUMS

THE Parks Branch of the Department of the Interior of Canada published thirty duplicates of the larger labels of those making up its Handbook of the Rocky Mountains Park Museum. This was done with the intention of offering them through the Museum of the Geological Survey, Ottawa, Canada, to the thirty then known museums in Canada. The survey offered the labels to the museums. Seventeen of them requested certain of the labels and were supplied, being given to understand that these labels were for use only until better labels were available. It is intended to publish from time to time a revised and more complete handbook and to print separates of a larger number of the labels composing it. An edition of at least sixty duplicates will then be desirable, as there are now known to be that many museums, counting both large and small, in Canada.

The writing of the labels and the type-setting of the first edition has already served twenty-two purposes, namely, to produce the handbook of the museum, to partly label the Rocky Mountains Park Museum, to place labels referring to the museum, zoo, paddock and park in the railway station and hotels at Banff, to label some of the animals in the zoo of the park, to label all the local animals in the paddock of the park and to assist in labelling seventeen other Canadian museums. There is a daily prospect of having requests for such

assistance from still other of the sixty Canadian museums.

HARLAN I. SMITH

DR. EDWARD HINDLE

TO THE EDITOR OF SCIENCE: In a review of Dr. Edward Hindle's book on "Flies in Relation to Disease—Bloodsucking Flies," by Mr. W. D. Hunter, printed in the issue of SCIENCE for July 16, there occurs the erroneous statement that Dr. E. Hindle met his death in Africa. Dr. Hindle is alive and well and occupies the position of divisional signal officer with the rank of first lieutenant in the Royal Engineers. He is expecting to leave for the front at any moment. It is clear to me that confusion has arisen through the death of Mr. Gordon Merriman, who likewise belonged to my laboratory staff. Mr. Merriman was killed while fighting in Nyasaland. Dr. Hindle has never been in Africa, although before the war we planned for him to go there on a scientific expedition.

Having received many inquiries, from different parts of the world, owing to the misstatement in SCIENCE, I shall be much indebted to you if you will kindly help me to quiet the apprehensions of Dr. Hindle's numerous friends by correcting the error referred to.

G. H. F. NUTTALL

CAMBRIDGE,  
October 10, 1915

#### SCIENTIFIC BOOKS

*Bodily Changes in Pain, Hunger, Fear and Rage; An Account of Recent Researches into the Function of Emotional Excitement.* By WALTER B. CANNON. New York, D. Appleton & Co., 1915. Pp. xiii + 311.

*The Origin and Nature of the Emotions, Miscellaneous Papers.* By GEORGE W. CRILE. Edited by AMY F. ROWLAND. Philadelphia, W. B. Saunders Co., 1915. Pp. vii + 240.

It is not altogether an accident that these two volumes, covering ground in many respects very similar, should appear at the same time. For a number of years, and particularly since the publication of Pavlov's work on the effects of emotion upon glandular action, there has been a wide and increasing interest among psy-

chologists and physiologists in the more intimate bodily mechanism underlying emotional processes. This movement has coincided with a rapidly growing appreciation among physiologists and physicians of the organic significance of certain of the so-called ductless glands, and of the physiological importance of gland and muscle tissue in general. Already the discoveries made have quite revolutionized many of the ideas of a generation ago, and the chapter seems hardly more than begun.

Despite the similarity of the two books, it will be convenient to discuss them separately, and we may first consider Dr. Cannon's work, which represents a series of researches carried on by the author in collaboration with a number of his colleagues to whom the book is dedicated. The work gives every internal evidence of having been done with great care and intelligence. The technique pursued is adequately described; the dangers and limitations to which it is exposed are frankly recognized, and the inferences and generalizations proposed are thoughtful and on the whole conservative. The only strictures which a psychologist might be tempted to pass would relate to the large psychological literature on the organic accompaniments of affective states, which is to all intents and purposes wholly disregarded. This may be because it was thought to have no bearing, but to the reviewer this position would hardly seem tenable. In any event, Dr. Cannon's work is written in a manner to inspire the highest respect for its conclusions, whether one wholly agree with them or not.

The essential positions of the author may be summarized in a few propositions, which nevertheless represent very extensive experimentation both of his own and of other scientists. The great divisions of the autonomic system, *i. e.*, cranial, sympathetic and sacral, represent three largely distinct functions in the economy of the organism. The first has to do with the storing up of reserves of energy for times of need, as is represented in the slowing of the heart beat under stimulation of the cranial connections of the vagus. The second is the great defensive organ through whose activity these reserves are rushed to the front



when needed. This is illustrated by the violent beating of the heart in anger, and by other activities of the organism discussed more fully below. The third has mainly to do with the preservation of the species, and involves the action of the sexual organs.<sup>1</sup>

Dr. Cannon points out that the sympathetic division operates antagonistically and inhibitory in its relation to the other two divisions, stimulating organs which they depress, or *vice versa*. Broadly speaking, it is the more imperious in its demands, and is likely, when in action, to dominate the others.

In connection with the operation of the sympathetic under the influence of pain or great emotional excitement, certain highly interesting glandular effects are observed. Adrenin is secreted and thrown into the circulation by the adrenal glands; additional sugar is also found in the blood. Experiments show that the adrenin is a powerful antidote to fatigue phenomena, and that it tends to drive the blood away from the abdominal organs into the lungs, heart and skeletal muscles, and that under its influence breathing is made deeper. It may be added that with these general conditions blood is found to clot more rapidly than under normal circumstances.

It has of course been a matter of general knowledge for generations that emotional excitement releases resources of muscular energy much in excess of those ordinarily at disposal. Human achievement in battle, in exciting sports, in terror and rage are all instances of this. These researches and others cited in support of the conclusions reached indicate more exactly the mechanisms by which the commonly observed results are actually brought about. Especially do they tend to magnify the office of the adrenal glands, organs whose functions have until recently been shrouded in mystery.

In common with other leading physiologists Dr. Cannon regards the sensation of hunger as due to contractions of the stomach wall in

contra-distinction to the other hypotheses in the field; *e. g.*, the theory that hunger is a general bodily sensation, that it is due merely to emptiness of the stomach, that it arises from hydrochloric acid in the empty stomach, etc. The chapter dealing with this topic, while intrinsically interesting, at first sight articulates with the rest of the volume somewhat indirectly. But when the distinction between appetite and hunger is remarked the relevancy of the material to the general theses of the book becomes apparent. Appetite has to do with suggestions of the agreeableness of food, in which sight, taste, smell and the activity of memory are definitely implicated. Hunger is a painful process which often, indeed generally, coincides with appetite, but it may exist without it, or may be wanting when appetite is present. Hunger springs from a definite local source, and involves vigorous action of the sympathetic. Appetite is more definitely psychical, and involves the cranial autonomic rather than the sympathetic. This distinction in the case of hunger and appetite affords a moderate instance of the antagonistic emotional interrelations which are often much more extreme and intense. Dr. Cannon elaborates these antagonisms by exhibiting various emotional expressions in which the sympathetic system is shown acting in vigorous opposition to the cranial and sacral. Perhaps the most striking instance is that of sexual emotion which despite its overwhelming power when once aroused can be inhibited absolutely by such activities of the sympathetic as are represented in fear and anger.

The author annexes as a final chapter to the book a discussion of alternative satisfactions for the fighting instincts and emotions. One is reminded of William James's brilliant paper on the moral equivalents for war. Like James Dr. Cannon concludes that the fighting instincts are too deeply inbred to be speedily exterminated, even if such extermination were thought wise. In order that they may not be perverted nor yet allowed to occasion unlimited human misery, by their normal expression, he advocates athletic competition of all kinds, and especially international games. The issue here

<sup>1</sup> One may suppose that Dr. Cannon does not regard as important the suggestions of certain scientists that these organs are in fact largely controlled by plexuses derived from the sympathetic.

raised stands on the whole somewhat apart from the main doctrines of the book and need not be further considered in this place.

Considering the work as a whole, the reviewer has only one caveat to offer, and that relates to the critique, both implied and explicit, upon certain features of the James-Lange theory of emotion. Taking Professor James's somewhat playful announcement that we feel afraid because we tremble or run away, a good deal of futile criticism has been expended in attempts to disprove the doctrine. The really significant feature of James's contention has by most of these assaults been left wholly unscathed; *i. e.*, the doctrine that the peculiar *modus* of emotion, as contrasted with other mental states, was to be found in the dominant part played therein by the reflex elements arising from bodily and especially from visceral sensations. Criticisms such as those of Sherrington and Cannon rest on altogether more substantial foundations than the earlier objections, and deserve more serious consideration. Sherrington has maintained, on the basis of his "spinal dog" that emotion may perfectly well be experienced when all connection of the brain with the viscera is estopped. Dr. Cannon maintains that the visceral agitation is very similar in many otherwise dissimilar emotions, and that in consequence we must abandon hope of finding in visceral sensations any differentia for the various emotions.

Reflexes of the facial and cranial muscles, by which in part at least Sherrington must have judged the presence of emotions in his dogs, are also instinctive and that is really James's important point, not that the reflexes are exclusively visceral. Visceral excitement, especially that of cardiac and respiratory character, undoubtedly often gives emotion its body and bulk. Moreover, even in emotions much alike in many respects and showing many visceral similarities, it is not clear that there are not abundant other differences, extending to the reflex conditions of the general skeletal system, and in no wise directly dependent upon purely cerebral activities. Sickening fear in the face of imminent peril has in it not a little

*yeah man*  
in common with the breathless excitement of the lover about to receive the first kiss of his beloved, but it also has many points of difference. In both there may be a fluttering of the heart and a quickened spasmodic breathing, but in the first there is generally relaxation of the tonus of the entire skeletal system; in the latter instance quite the contrary may be the case, and the skeletal system may be toned to an extremely high pitch.

Until it is shown that consciousness is not characteristically modified in emotion by excitation reflexly aroused whether in skeletal muscles, glandular activities or visceral organs, the main point of James's doctrine will stand firm. Neither Cannon's nor Sherrington's contributions seem to the reviewer to accomplish this.

Dr. Crile's volume, comprising eight addresses delivered from time to time during recent years, is much more loosely integrated than the studies by Dr. Cannon. The essays vary greatly in present value, and connect themselves with the subject of the emotions in very different degrees. One gets the impression that Dr. Crile either is not widely read in modern psychology, or that he attaches very slight value to its literature. Certainly the essay entitled "The Mechanistic View of Psychology" suggests only the slenderest acquaintance with the contemporary views on this issue, and contains, so far as the reviewer has observed, no material not already more forcefully expressed by other writers, especially by Dr. Loeb. In one passage,<sup>2</sup> he says: "Could we dispossess ourselves of the shackles of psychology, forget its confusing nomenclature, and view the human brain, as Sherrington has said, 'as an organ of, and for the adaptation of nervous reaction,' many clinical phenomena would appear in a clearer light." It is not clear what special psychological shackles Dr. Crile is dragging, but the reviewer is at a loss to think of any psychologist of note who would for a moment call in question the formula quoted from Sherrington. Meantime the book, which in portions is over-illustrated with cuts of the kindergarten type, contains a large amount of

<sup>2</sup> P. 48.



admirable material gathered by Dr. Crile and his fellow workers. Much of this is put in fresh and interesting form, but many of the inferences and conclusions based on the facts appear at best quite imperfectly substantiated, and the reader more than once feels the absence of that logical sobriety and reserve which gives Dr. Cannon's book so scientifically satisfactory an atmosphere. Perhaps the most significant facts cited by Dr. Crile are connected with his brilliant surgical experiments on anesthetics and particularly on the use of cocaine to block spinal cord conduction.

In the opening essay on phylogenetic association in medical problems, the main doctrine presented is that racial history has determined the kind of responses made to injurious and threatening stimuli, most of them expressed in emotional activities, and that these resemble in their cerebral cortical consequences the effects of ordinary surgical shock. The latter is found productive of brain injury in ether anesthetization, despite the painlessness of operations under these circumstances; in less degree with nitrous oxide, and to all intents and purposes not at all with his own anoci-association methods of cocaine injection in the spinal cord. Many side issues are touched upon, for example, the phylogenetic history of the struggle between bacteria and their hosts, the history of fear as phylogenetic struggle, etc.

Then follows an address on phylogenetic association in relation to emotion, presenting a doctrine of essentially Darwinian character. Emotion is a vestige of an old and formerly useful act now partially or wholly inhibited and aborted. The author comments suggestively on the alleged fact that animals which have no natural weapons for attack experience neither fear nor anger, while animals which have weapons of attack express anger particularly by energizing the muscles used in attack.

The essay on pain, laughter and crying again evinces either lack of familiarity with, or profound distrust of, the extensive psychological literature dealing with the second phenomenon at least. The doctrine of the protective character of these acts is further developed, and

pain is identified as a motor phenomenon with the repeated discharge of brain cells; crying and laughter furnish drainage for dammed up excitement not otherwise conveniently disposable.

The paper entitled "The Relation between the Physical State of Brain Cells and Brain Functions" is an exposition of the doctrine that the cortical cells show most injury in all forms of organic disorder involving the higher mental functions. The essay on the "Mechanistic View of Psychology" has already been referred to.

The essay on the "Mechanistic Theory of Disease" formulates a conception of organic processes which, so far as the reviewer can detect, is substantially identical with that offered by Descartes in 1664.

An address on the "Kinetic System" is a long and rather loosely organized discussion of the thesis that "there is in the body a system evolved primarily for the transformation of latent energy into motion and into heat. This system I propose to designate 'the kinetic system.'"<sup>3</sup> The principal organs of this system are the brain, the thyroid, the adrenals, the liver and the muscles. "The brain is the great central battery which drives the body; the thyroid governs the conditions favoring tissue oxidation; the adrenals govern immediate oxidation processes; the liver fabricates and stores glycogen; and the muscles are the great converters of latent energy into heat and motion." The essay is devoted to a citation of evidence from various sources to substantiate these conceptions, with the constant context that the adaptation of animals to environment involves transformations of energy, in which the organs named are the all important factors.

The final address on alkalescence, acidity and anesthesia is a defense of the doctrine that life depends on the maintenance of normal potential alkalinity and that anesthesia is primarily a function of increasing the acidity of the organism.

The volume as a whole suggests an intelligence of unusual originality and force, somewhat hurriedly and with undue disregard of

<sup>3</sup> P. 174.

the large relevant literature of the subject, dealing with ideas which richly deserve a more leisurely and scholarly development. It is to be hoped that Dr. Crile may in the near future find time for such a treatment.

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### SPECIAL ARTICLES

#### A STERILE SIPHON TIP PROTECTOR

THE tip of a siphon supplying sterile water, physiological saline solution, or diluent (0.4 per cent. tricresol in 0.85 per cent. NaCl solution) for various bacteriological procedures must be protected from contamination by dust, flies or other unsterile objects. This is accomplished fairly successfully with a bell-shaped cap such as can be made by cutting the bulb of a 50 c.c. volumetric pipette in the middle, leaving attached to each bell a tube 5-7 cm. long for union with the siphon tube, and drawing into this tube by means of a suitably sized rubber hose, another glass tube of such size that when the rubber hose is released its elasticity binds the two together. The covered end of the smaller tube is then adjusted even with that of the bell tube and the rubber hose snipped off, or in fact used to connect to the siphon of the bottle.

But such a device, while giving a fair protection during use, does not prevent the lodgment of upwardly floating particles of lint upon the drop of liquid at the point. It is this protection which the following addition accomplishes.

A test tube about 2.5 cm.  $\times$  15 cm. may usually be found to fit outside or inside the bell, as above prepared. The lip is removed and upon the tube is placed a thin rubber finger cot or a finger of a rubber glove from which the closed end has been cut so that the portion which is left may be rolled upon the bell from the tube thus holding the two together and preventing lodgment of contaminating dust when the siphon is out of use. During use the protector may itself be protected by fastening it to another test tube. However, this is scarcely necessary, and I have ordinarily taken no particular precautions to

sterilize or prevent contamination of the protector since it touches the bell only and not the siphon tip itself. Yet in certain permissible cases a few drops of formaldehyde in the protector have added a further element of safety.

One of the special purposes to which I have successfully adapted such a device is the frequent examination of bacterial broth cultures being studied for progressive metabolic and morphological changes. For example, some of the fluid from a liquid preparation of *B.*

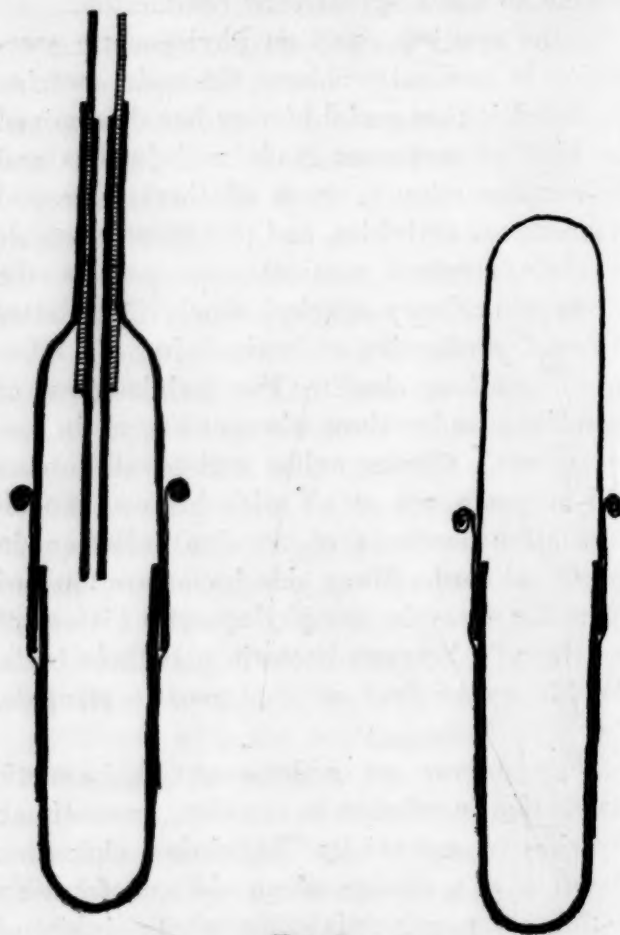


FIG. 1.

*diphtheriae* was withdrawn every four days for a period of three weeks, microscopic and cultural examinations made at each withdrawal confirming the continued purity of the contained culture.

Fig. 1 shows a diagrammatic cross section of the apparatus set up (A) and taken apart (B), for use of the siphon.

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